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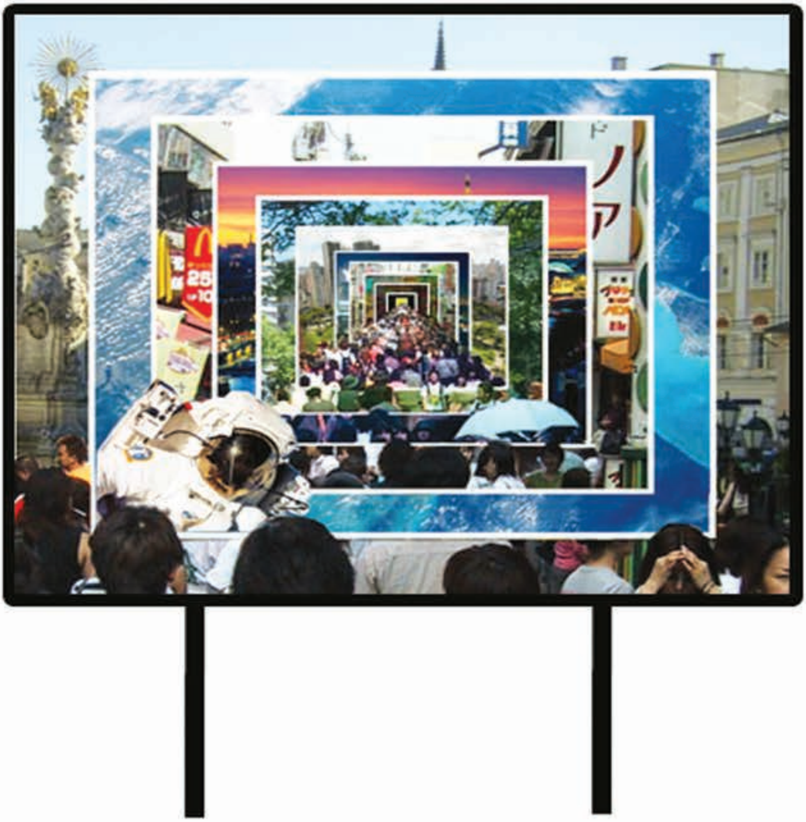

SPECIAL ISSUE:

Data-driven Cities? Digital Urbanism and its Proxies

Ouroboros (2008) by Alvaro Cassinelli

"Ouroboros" is a shared virtual space, a world-scale tunnel built by chaining video-conferencing cameras and projectors in a closed loop around the world. This virtual space comes into contact with the Earth at several entry points or "Gates" situated in different cities, each standing in a location particularly representative of the place (public squares, markets, private homes, etc). Each Gate is simply composed of a projection screen, a video camera a little far away, and an "interstitial" public space in between. The camera captures the whole view – that is, the passersby and the standing projection screen blended in the background – and the resulting live stream is sent over the Internet to be projected onto a similar structure – in a different city, in a different country, in a different continent. The process repeats itself until the loop is completed, as the final video is projected back onto the first screen – only to restart a tour in an eternal circulation. In its (almost) instantaneous travel around the world, the video stream will gather "souvenirs" of the visited places. People from all around the world will appear on the screen as standing in the middle of a tunnel whose walls are composed by an infinite recursion of (Matryoshka-like) nested video windows; one can recognize the actual location of the shooting in each of these rectangular frames.

http://www.alvarocassinelli.com

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Cover *Ouroboros* by Alvaro Cassinelli

Special Issue

Data-driven Cities? Digital Urbanism and its Proxies

Edited by Claudio Coletta, Liam Heaphy, Sung-Yueh Perng and Laurie Waller

Scenario

Crossing Boundaries

Book Reviews

Data-driven Cities? Digital Urbanism and its Proxies: Introduction

Claudio Coletta
University of Antwerp (BE)

Liam Heaphy
Maynooth University (IE)

Sung-Yueh Perng
Maynooth University (IE)

Laurie Waller
Technical University of Munich (DE)

Abstract: If 'big data', 'smart cities' and 'data-driven cities' are merely useful buzzwords, they nevertheless evidence an expanding chatter of heterogeneous voices who are merging with and reshaping the urban environment. This introduction addresses the data-driven city by focusing on the concept of proxy to articulate its multiplicity. We then provide an overview of the contributions included in this special issue, highlighting how they account for the particular sites where relations are made between knowledge practices, infrastructural developments and administration and management. Rather than take a stance with respect to particular definitions of the data-driven city – or its more commercial inflections as 'digital urbanism' or the 'smart city – in this special issue we suggest there is value for urban research to draw on STS approaches in attending to the sociotechnical fuzziness of data as it falls between epistemological problems, material infrastructures and organizational concerns. We conclude by suggesting possible directions for further research.

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Keywords: data-driven cities; proxies; open data platforms; citizenship; technical democracy.

Corresponding author: Claudio Coletta, University of Antwerp - City Campus, M.386. Sint-Jacob straat 2-4, 2000 Antwerp – Belgium. Email: claudio.coletta@uantwerpen.be

1. Cities by Proxy

The 'data-driven city' is a multivalent concept. To some, the data-driven city draws attention to the recent expansion of urban disciplines and their public influence in the business of cities. To others, the data-driven city re-

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fers to the proliferation of computing infrastructure in urban environments and the possibilities for novel forms of interaction between communities. Other versions of the data-driven city can be found in developments in city administration that build on longstanding data collection practices and problems of city management. Still more versions of the concept abound in the technology and energy industries. This special issue presents a collection of empirical papers, interdisciplinary dialogues and book reviews that grapple with particular conceptions of the data-driven city, as well as practical attempts to realise its value, govern its uncertainties and resist its excesses.

Rather than take a stance with respect to particular definitions of the data-driven city – or its more commercial inflections as 'digital urbanism' or the 'smart city' – in this special issue we suggest there is value for urban research in attending to the sociotechnical fuzziness of data as it falls between epistemological problems, material infrastructure and organizational concerns. Spotlighting 'the data' has widely (although not exclusively) been a strategy of urban research driven by instrumental aims in social policy, planning and economic development and rarely exhibiting much concern for the contingencies involved around data collection, processing and application. Indeed, the ease with which we can detect traces of positivism in the work of the very researchers heralding a paradigm shift to a new computational urban science (e.g. explicit in Pentland 2014) might help explain why some versions of the data-driven city feel distinctly familiar and at times surprisingly unsophisticated (see Farias and Widmer this issue). As contributors to this special issue widely highlight, the data of the data-driven city rarely appear "raw" (Gitelman 2013); and where they do, this is often a highly fabricated, materialized and contingent accomplishment (Denis and Goëta 2017; Courmont, Marquet and Reed this issue). In other words, (big) data need to be considered as part of an assemblage (Kitchin 2014).

The erasure of the artifices of the data-driven city may be a common characteristic of positivist urbanisms (new and old) but it has also long been a key tenet of commercial and political strategies that seek to promote and exploit cities as information economies (Castells 1996). One of the central arguments of this special issue is that attending to the social and technical contingencies of the data-driven city would be of little critical consequence if its artifices are simply bracketed as 'local context' (e.g. "let 100 data-driven cities bloom!"). Rather, we propose that examining the construction of the data-driven city (in all its variations) also requires accounting for the ways in which this concept has circulated across the globe, not only making relations between diverse governmental authorities but also between the practices of urban disciplines, the engineering of digital infrastructure, and city management and administration. We ask in what ways can mass-market measurement devices reconfigure issues like air pollution in cities as diverse as New York, Rio de Janeiro and Dublin? Can data infrastructure, like sensor-networks, provide an apparatus for the circulation and exchange of technical expertise? How do city managers address uncertainties introduced into urban environments by ‘off-the-shelf’ smart city technologies such as government data platforms and energy monitoring systems?

In this special issue, we propose the concept of ‘proxies’ as a tool for interrogating the data-driven city as it is assembled as a sociotechnical artefact. Search the web for the word ‘proxy’ and you will likely return a list of companies offering ways to either browse the internet anonymously or access blocked content using intermediary servers. Today, the proxy is a core concept in the technical design of computer networks and the transfer of data between distributed locales. However, like so many things digital, internet proxies are infrastructure technologies that often come with particular forms of sociality hardcoded. Conventionally, the concept of the proxy described a particular form of social relation: a delegation of agency from one party to another and an indirect, or mediated, exercise of power. Like many technical components of digital infrastructures, proxy servers are widely invested (more or less explicitly) with particular social and cultural ideas about networked order (Bowker and Star 2000; Kelty 2008; Turner 2010). Users of internet proxies, for example, are often encouraged to understand them not only as mere intermediaries that facilitate flows of information but also as points of “data friction” (Edwards 2010) where, for instance, entities like IP addresses can be manipulated (anonymised or distorted). In addition to reasons of personal privacy, users may seek to preserve their anonymity to disrupt surveillance regimes or route around legal regulations and state censorship (cf. Van de Velden 2016). Indeed, it is not surprising that surveillance should be one of the key themes emerging in this special issue (see Evangelista et al.).

Our proposition is that to begin to understand the political and commercial affordances of the smart city we need to examine the particular *sites* (see White this issue) where relations between knowledge practices, infrastructural developments and administration and management are made, entangled or disentangled and sometimes obfuscated. Proxies are points of connection that facilitate flows of data but, as many contributors to this special issue point out, they are just as often points of bifurcation between heterogeneous networks and boundary markers between collectives.

One of the gambles of this special issue is the proposition that knowledge practices, infrastructure and management programmes developed in the name of ‘digital urbanism’ or the ‘smart city’ are as riddled with glitches, distortions and data-loss as they are competing social and political conceptions what the data-driven city is for and who it serves. While collaborations between the technology industry and city administrations often promote data-driven solutions and the renewal of technocratic governance and political managerialism (Morozov 2013), contributors to this special issue highlight that deployments of data for addressing urban issues often draw attention to those settings, practices and technical arrangements through which governmental and managerial power is derived and their messy contingencies negotiated. Whether investigating the heterogeneity of urban data infrastructures (Shapiro this issue), comparing “off-the-shelf” pollution sensors (Reed this issue), engaging with design to develop a methodology for high quality urban environments (Hick et al. this issue), or creating smartphone games for CCTV sousveillance (Evangelista et al. in this issue), contributors to this special issue highlight the diverse ways in which proxies of the data-driven city both mediate the construction of urban issues and delegate the ability to act on them.

The second proposition that we wish to make is that a focus on proxies allows us to enrich our understanding of the indeterminacy and precariousness of contemporary smart city endeavours and achievements. A plethora of digital data-driven or data-aided sociotechnical systems are now in place, and further systems are continually being tested and trialled at varying scales in real-life urban settings, informing decision-making and involved in the performance of the spatial, material, and temporal dimensions of the urban. We especially refer to the formation and proliferation of “code/spacetimes” (Kitchin this issue) where software is a constitutive component of urban life, highly visible in control rooms, city dashboards, mobile apps and sensing networks, which in turn enact new forms of citizenship and governmentality (Gabrys 2016). The interplay of big data infrastructures and organizational processes contributes to increase the heterogeneity of “urban assemblages” (Farias and Bender 2010). The uncertain and mutable existence of such assemblages makes urban spaces typically “experimental” (Evans et al. 2016): cities become expanded laboratories where different sustainable, prosperous and liveable urban futures can be tested in the real world. Singapore, Barcelona, Dublin, and San Francisco are but few examples of cities undertaking experimental modes of development.

In these cities, experimental urbanism is often developed through combinations of networked infrastructures with economic development strategies seeking to foster entrepreneurship, and in some cases national identity. This combination has led to the adoption of pre-commercial procurement, hackathons and testbedding to prototype the urban at different scales, from ‘smart districts’, living labs, open innovation initiatives, developed in and for global cities such as Dublin, Boston, New York, and Paris to nation states such as India or Singapore as a city-state. While such rhetoric of experimentation often make gestures towards the openness of smart city programmes to public participation, various contributors to this issue note that the experimental processes developed through these programmes are often driven by deeply instrumental aims that both circumscribe the ‘public interest’ and limit the articulation of public concerns. While procurement is increasingly said to be becoming problem-oriented, the definition of what counts as a valuable problem is often left to the market, blurring distinctions between public and private interests. It is therefore perhaps not surprising that various contributions could be read as indicating the emergence of new forms of ‘public agnosticism’ as a response to the atmospheres of uncertainty and anomie promoted in smart city experiments. The appearance of the Public as a weak actor with scarce resources to critically test urban solutions coming from industry, research or 'the market' arguably echoes debates about the capacity of democratic societies to deal with technological change reaching back to the early 20th century (Lippmann 1927). It would of course be a mistake to imagine that urban experimentation somehow plays out as a zero-sum game between public and private interests. As many contributions to this issue highlight, commercial actors are far from being a homogeneous group. For instance, broad shifts in local government from service provision to procurement have widely contributed to redefining what counts as commercial activity, and corporate aims often come into conflict in experimental processes. The creation of intermediaries able to orient and prioritize urban innovation strategies; the contradictions of "transparency by datafication" with the reuse of open data by the private sector; and finally, the role played by STS in engaging with and articulating these contingencies, as discussed in the *Crossing Boundaries* section by Young, Hoyng, Blok and Minor, offer tools and materials for reflecting upon these issues.

Under the rubric of urban experimentation, hackathons and other 'open innovation' events also make promises to solve urban problems by adopting a citizen-centric and co-production approach that celebrates a new horizon of citizen engagement. In practice, however, municipality-led participation initiatives rarely aim at problematizing competing political understandings of citizenship, and are instead more economically focused on the exploitation of highly skilled labour. In such initiatives, as described by Farias and Widmer (this issue), citizens are often invited to propose technical prototypes and are valued principally as providers of data or ideas (Perng forthcoming). It is understandable why a certain cynicism about participation might result from initiatives where the engagement of citizens is driven by municipal aims to marketize city infrastructure. A vision of citizenship based on 'productive' forms of collaboration with central and local governments has provided an important focus of smart city developments. Such a vision (and the participation practices it initiates) requires critical attention. As several contributors to this issue argue, aims to make citizen participation productive in smart city programmes – whether citizen science, civic hacking or 'making' initiatives – may not always be compatible with other governance aims of extending transparency and enhancing the accountability of administration actions. The question of how urban issues are defined and who owns the tools to act on them is unlikely to be answered by participation programmes that simply attempt to convert private individuals into 'active' citizens.

Initiatives to improve the openness, transparency and effectiveness of urban knowledge, governance and service delivery have typically expanded the open data franchise, produced new tools and technologies, and availed of citizen sensing, hacking or crafting communities.

2. The Contributions in this Issue

The development of these sociotechnical proxies and practices therefore leads to many of the questions this special issue seeks to address. To what extent cities are understandable through data? How do software and space interact in everyday urban life and urban management? How do data and policies actually shape each other? With many rich contributions, the special issue seeks to shed light on the multiple enactments and proxies of such experimental urban and data assemblages which affect the way time, politics, economy, design, engagement, control and knowledge are performed in diverse empirical settings.

As we see in Rob Kitchin's opening lecture, smart city technologies produce new timescapes. Kitchin unfolds the notion of ¨real-time city¨ as a constructed temporal condition "transforming management and governance of city systems and the pace, tempo and scheduling of everyday life": acceleration, simultaneity, colonization of dead time and decoupling from clock time are typical of the condition enacted through ICT in cities. The cases of the traffic control room and intelligent transport systems are emblematic for understanding how the temporal pulses of the city are maintained and adapted, as well as for observing the multiple latencies that take place. Through generating, recording, measuring, and sharing real-time data from cameras and sensors to regulate traffic flows and minimize congestion, they produce an accumulation of microseconds that in turn creates asynchronous code/spacetimes that need to be continuously readjusted. In practice, they are never quite in real-time and these temporal missing masses compose varying forms of "realtimeness", namely distinct "real-time cultures" within platforms and systems.

A second, though not secondary, aspect involves the kind of politics attached to and detached from smart city discourse, this being the focus of Ignacio Farías and Sarah Widmer's lecture. They unfold the question mark of "*Data-driven cities?*" by a combination of decoupling smart and data-driven cities and moving beyond governmentality as a lens to observe contemporary urban development. Drawing on Latour's cosmopolitical framework, their proposal addresses the city as a "multiple object, where different forms of governing, knowing, valuing and practicing the city interact and enter in conflict with each other". Accordingly, big data initiatives, smart urbanism and the non-digital logic of many civic engagement processes are often disentangled in shaping the urban. Exploring the trajectories of two actually existing instances of smart urbanism – the first on Foursquare, and the second, on Smarter Together – they account for the unconventional character of "ordinary smart cities".

In the *Essays* section, the contributors continue to unpack the multiple and problematic unfolding of data-driven technologies. We have generally assembled papers with a theoretical and critical analysis of data-driven cities yet also include more practice-based and playful pieces as a means of teasing out and emphasising how cities reconfigure these technologies and also become reconfigured in the process.

In the literature on smart cities it is not uncommon to find computational metaphors applied to urban processes (for instance, the idea that cities could have unified "operating systems" – Townsend 2013). Shapiro interrogates the extension of the computing term "stack" to analyse the structure of the data-driven city. Through the "urban stack" Shapiro aims to explore what is beneath and behind the interface so as to identify the "digital-material assemblages" that produce data-driven cities. Shapiro reconfigures the concept of the "stack" in a broader and more heterogeneous way to capture the different ways in which both digital and non-digital objects, practices, technologies, institutions and infrastructures are assembled to enable data flows. His proposition is empirically grounded in two case studies: LinkNYC, a Wi-Fi infrastructure in New York generating real-time locational data to be used for advertising purposes, and fleet management algorithms acting as invisible layers of control in the on-demand economy of taxi hailing. While distinctively different, the two case studies together provide a critical understanding of how the soft, distributed infrastructures, including consumers, workers, laws, regulations and public institutions are enrolled into and also exploited in the enacting of calculated, passively experienced, controlled, surveilled and instrumentally rationalized cities.

Sensor networks are often characterized as a distinctive infrastructure of the smart city, and have been foregrounded in attempts to link technological innovation with environmental sustainability. Reed's contribution explores how environmental sensing infrastructure can 'script' the competences of its users. Taking a moment of infrastructural breakdown in the installation of an urban pollution sensor network, Reed describes how concerns about a lack of public data literacy led engineers to manipulate the patchy data produced to appear more complete than it was. Highlighting the multiple ways in which sensor-produced data are routinely manipulated, Reed proposes the promotion of data literacies that do not fetishize 'raw' data. Rather, Reed argues, data literacies should instead encourage sensitivities to the ways in which such data 'glitches' provide moments for creative interaction between technology, the built environment and urban publics.

The design-based piece from Adam Urban, David Hick, and Jörg Rainer Noennig is partly a counterpoint to the more critically focussed papers. Like Mueller von der Haegen and Peter Sloterdijk's (2005) pneumatic parliament that could be deployed within 45 minutes to conflict zones, it technicises problems that are cultural and organisational as much as they are technical. Although a serious piece with intent of developing further, its utopian thinking brings up the challenges we see everywhere with smart technologies; the replacement of human mediators (in this case, planners) with digital platforms, data analytics, and claims to equitable participation. Where Uber sidelines regulators and trade unions and empowers those outside, so might data-driven design reduce the planner to that of "data concierge". Nevertheless, it addresses key concepts concerning the computational drive into architecture that recalls debate on computational design and algorithmic architecture, only in this instance applied at the neighbourhood scale. We trust that it will be read in a context of experimentalism, counterbalancing our smart city critiques with smart city creativity from professional architects.

The contribution by Evangelista, Soares, Costa Schmidt and Lavignatti continues the examination of data-driven cities by engaging with design practices. They combine game studies and surveillance studies to propose a smartphone app called DIO to enable 'sousveillance' practices and civic hacktivism. The game starts with a dystopian scenario where all the data converge in a system called Digital Information Operative (DIO) that integrates public surveillance devices around the planet. Clearly inspired by Edward Snowden's revelations, DIO is also a reflexive tool for understanding locative media and privacy issues related to contemporary urban life. Reflexivity also engages with what it means for an academic community to engage with the design of Massively Multiplayer Online Games and location-based games as a sociological experiment to 'game' the surveillance culture.

The *Crossing Boundaries* section provides a space for exchanges between researchers studying public and open data platforms and the implications for urban governance. Contributors to this section offer a series of joint reflections on public and open data platforms across a variety of cases: from cycling, traffic and digital mapping to activism, environment and data brokering. Often linked to open government initiatives, data platforms are frequently proposed both as mechanisms for enhancing the accountability of administrations and as sites for bottom-up digital invention. However, such promises of smooth flows of information, enhancing transparency, collaboration and interactivity rarely materialise unproblematically. The development of data platforms is always situated in particular administrative cultures, access always involves processes of social negotiation, and interfaces (such as sensors) may become objects of contestation. In this section, contributors draw attention to some of the substantive issues driving the development of public and open data platforms and shaping their deployment, as well as highlighting the limitations of urban governance programmes.

The opening contribution from Anders Blok and Kelton Minor recognises the changing framework around big data, expanding from discourses of technological development and deployment to that of reconstituting social relations through technology. They discuss efforts by the city of Copenhagen to harness new data infrastructures to advance their already advanced modal shift to cycling in the interests of climate change mitigation and to secure their reputation of environmental leadership. Blok and Minor discuss how their previous work within a large project on social networks, based on volunteered smart phone data, can feed into further projects and the ethical implications involved with data re-use. In particular, their piece draws attention to how these encounters of STS research with the urban lead to further reflexivities on the agency of STS in an age of data ubiquity and cross-disciplinary meetings.

The "awkwardly engaged encounters" and the socio-technical relations of big data described by Blok and Minor are observed by Antoine Courmont as modalities of circulation, production and re-use. Describing a case of traffic open data, Courmont explores the interplay of attachment and detachment that allows the actionability and accountability of data across different publics with different representations of urban space. This perspective offers an opportunity to rethink information liberalism, emphasizing the dependent, non-neutral and materially inscribed character of data.

Ideologies of information liberalism are also the object of critique in Rolien Hoyng's contribution, which explores the links between open data and the politics of transparency. Hoyng highlights how smart city open data initiatives widely instrumentalize transparency discourses in ways that often empower further, rather than hold accountable, governing powers. Affirming the disruptive and "messy" qualities of digital urbanism, Hoyng advocates for data-activism premised on seizing and freeing data in ways that allow open data to perform as a site and medium for political contestation and struggle.

As the contributors to this section highlight in different ways, producing data requires work. The focus on "data labour" in Clément Marquet's contribution makes this aspect explicit. Marquet examines the forms of labour that are invented in the collaboration between Transilien, a public transportation operator in France and OpenStreetMap France. In a trial and error process of data production, various forms of labour are created and enrolled – from informal ones such as leisure and volunteering activities to formalised contracts and the use of professionals with specialist expertise. As Marquet further demonstrates, these actors and their labour are also crucial in "an ecology of data maintenance", trigger "tag wars" (who owns which tags on the map), and also demand the intermediaries of Transilien agents to maintain the correspondence between new data inputs and reality.

Like Hoyng and Marquet, Christian Nold's contribution highlights the limitations of governance approaches to account for the multiple, and often conflicting, practices of deploying data platforms to address urban issues. Nold examines the proliferation of what he terms "neo-environmental" sensing in which cheap and often low quality sensors are used for public data gathering on environmental problems outside of government mandated monitoring programmes. In a case study on airport noise campaigners, Nold highlights that the power of these sensing devices lies not in so much in precise measurements of particular material pollutants but in their networking capacities and in the production of affective visualizations. Despite the limited value of such devices for governmental monitoring programmes, Nold proposes that neo-environmental devices nonetheless provide platforms through which the 'sensation' of airport noise can be publicly articulated and evidenced.

Continuing to observe the mutations of public-private relationship, Meg Young addresses the open data initiatives promoted by government agencies. While, as Young makes clear, it is undeniable that open data programmes widely promote economized understandings of the 'public interest' and privilege corporate actors as drivers of social change, the author's empirical study of an open data network in Seattle also highlights that the commercial value of such platforms does derive solely or principally from data made accessible for public use. Rather, Young describes how private interests are mediated through attempts to set standards for local government data platforms, thereby producing a number of data-brokers that set standards and profit from the preparation and release of open datasets. While increasing usability and interoperability across agencies, such standards afford an exclusive set of corporate actors the power to both unlock the commercial value of municipal data and act in the public interest.

Standards are the theoretical concern of the *Scenarios* section, where we invite the reader to make a move from issues related to the urban to issues related to spatiality itself and its making. James Merricks White proposes a site-based methodology to study standards and standardization. He draws on Karen Barad's agential realism, with standards considered here as a material-discursive apparatus of bodily production, involving both human and non-human bodies. Thus conceived, the approach looks at human and voluntary standards as a narrow subset of what a standard actually does and is, with network addressing standards such as IPv4 and ISO 9001 seen as entangled sites which come into existence through iterations. White's contribution is especially relevant considering the entangled sites where multiple (organizational) bodies, (public and private) agencies and infrastructures collide and intra-act to set the standards for what an allegedly desirable, innovative and smart city should look like.

Finally, the Book Review section includes the contributions by Caspar Menkman on Jennifer Gabrys' *Program Earth*, that of Claudia Mendes and Pim Peters on Evans and colleagues' *The Experimental City*, and the combined review by Susann Wagenknecht on Krajewski and colleagues' *Dienstbarkeitsarchitekturen. Zwischen Service-Korridor und Ambient Intelligence,* and Meier and Portman's *Smart City. Strategie, Governance und Projekte.*

3. Conclusion

The present ubiquity of sensors and computing devices moves in tandem with an increasingly powerful and extended multiform network of organizations, technology creators, epistemic communities, advocacy coalitions and users (Kitchin et al. 2017). If 'big data' and 'smart cities' are merely useful buzzwords, they nevertheless evidence an expanding chatter of the multiple voices who are merging with and reshaping the urban environment. The contributions included in this special issue offer a grounded account of various partnerships between city administrations, technology companies, civic activists and academics, among others. They unpack the different proxies and practices of data-driven cities and demonstrate how data-driven systems and schemes are deeply contested and have never been neutral and apolitical: (big) data and the ahistorical, aspatial, homogenizing vision of cities are problematized for recognizing how they are situated in the multiplicity of actual digital urbanism.

The politics of data, data analytics and visualization performs within specific urban and code assemblages embodying specific versions of real-time and anticipatory governance. The proxies and practices that are in play and examined here range from the sophisticated multi-purpose digital monoliths featured in Shapiro's contribution to the rudimentary noise sensors described in the paper by Nold. Where the former are becoming the first visible and interactive manifestations of a new urban technology wave led by natively digital corporations, the latter reflect the increasing means at the disposal of concerned citizens who wish to articulate new issue-publics (Marres 2012) and new ontologies. Echoing the concerns raised by these citizens and amplified by the contributions, we look forward beyond this special issue to new critical perspectives on a number of issues.

The first one involves the disparities of scale, such as that between large urban systems and piecemeal civic projects. Where the former may subtly manipulate millions of human bodies in the synchronised performance of urban life, the latter may be far less powerful one-off projects associated with civic hacktivists, political actors, and other concerned individuals or collectives. The disparity might also be between widespread (and often taken-for-granted), and alternative sociotechnical imaginaries, upheld across different public/private actors and organisations, have the potential to strengthen or potentially challenge existing proxies for the production and circulation of data. The quality of democracy enacted by the heterogeneous urban proxies is then a matter of redistributing and articulating the calculative as well as the political agency of data-driven initiatives.

The articulation and redistribution moves are connected with the management and governance of uncertainty in urban development and the delivery of services. What is uncertain and contested is not necessarily unmanageable, and the second issue considers the capacity to include different publics into a common space as well as other initiatives not included in smart city discourse but critically relevant to it. To date, we note the expansion of IoT networks, control rooms, hackathons, city dashboards, and the development of smart districts which herald future change, yet also a rather subdued critical response from wider civic society. The challenges and the testbedding initiatives undertaken by city administrations are somewhat localized and disconnected from planning policies, and ultimately not ambitious enough with respect to actual needs in terms of work, mobility, environmental quality, and housing.

The third issue addresses the neoliberal elephant in the room. The specific ways in which data-driven innovations have been, and can continue to be, leveraged to legitimize the ongoing neoliberalizaton of urban governance requires further empirical and theoretical examination without using neoliberalism as an analytical shortcut. Looking closely, it may turn out that neoliberalism is not so much an elephant as it is an issue with how the room is arranged, and one of the aims of this special issue is to detach the big neoliberal assemblage starting from its specific, multiple and mutable proxies. This means, while unpicking similar rhetoric on efficiency or cost-effectiveness, it is also important to pay attention to any emerging means by which new markets are being created, often in unpredictable places. Similar to the re-constitution of the public, government and social relations, markets and market practices can be re-constituted through data-driven technologies. The proxies and practices that are then invented to exploit new forms of measuring, valuing and performing labour require new analytical lens grounded in empirical investigation to tease out the inventiveness of neoliberal proxies and their extension of market logic to urban governance.

Fourth, it is also important to consider emergent sociotechnical practices within, around or peripheral to the large networks and platforms as proxies that might challenge our assumptions, imaginaries and discourses about what it means to be ethical. The focus on practices, however, does not imply a dissolution of responsibility. Rather, it suggests one of the possible means to help ensure that the design, engineering, planning, regulation, and governance of these networks, platforms and cities are informed and inspired by socially-driven values and principles.

Academic perspectives thus can look not only towards how and where neoliberal inventions are made and where contestations against them arise, but also towards the underlying ethical frameworks which underpin large technical systems such as social networks and open data platforms. In a new age where large-scale political manipulation and distortion can be conducted with relative ease through the exploitation of the creations of naive digital evangelists, it may be that the future urban systems becoming commonplace in our cities will not expose false hopes of ethical neutrality and instead be purposely driven by specific shared values and principles.

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The Realtimeness of Smart Cities

Rob Kitchin
Maynooth University (IE)

Abstract: This essay considers the notion of a 'real-time city' from a temporal perspective. The essay is divided into three sections. The first section examines how smart city technologies seek to utilise real-time computation to transform urban management and governance and the pace, tempo and scheduling of everyday life. The second section considers how ICTs are transforming the nature of time with respect to smart cities. It sets out a set of related notions of real-time temporalities (network time, chronoscopic time, instantaneous time, timeless time, machine time, code/spacetime) and unpacks the nature of 'realtimeness' and the relational, contingent, and heterogeneous nature of real-times operating across smart city platforms and systems. The third section discusses the politics of adopting real-time technologies in urban management and the conduct of everyday life and sets out arguments for the maintenance of asynchronous cities and the adoption of an ethics of temporal dissonance. The conclusion argues that there is a need for philosophical, theoretical and empirical work to understand the realtimeness of smart cities and sets out a number of questions that might guide such research.

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Corresponding author: Rob Kitchin, MUSSI, Iontas Building, Maynooth University, Maynooth W23 F2H6, Ireland. Email: rob.kitchin@mu.ie

1. Introduction

Starting in the 1950s with the nascent shift from electro-magnetic to computational systems, digital technologies have been used to understand and manage city services and infrastructures, with processing and reaction becoming progressively more timely. In the late 1960s, the promise of digital developments dovetailed with cybernetic thinking, in which the city was envisioned as a system of systems that could be computationally managed (Forrester 1969). Each system, it was argued, could be broken into its constituent parts and processes, be modelled and simulated to capture its essence and to plan and operate its functions. In practice, cybernetic efforts to reform city planning and administration largely failed to materialize, in part because how cities work is more complex, contingent and socio-political than the models permitted (Flood 2011; Townsend 2013). Nonetheless, throughout the 1980s and 90s computation progressively continued to be embedded into the working practices used to plot and manage cities and into the infrastructure used to deliver essential services – such as the use of SCADA (supervisory control and data acquisition) to monitor and control utilities and GIS (geographical information systems) to document and analyse land use and the spatial constitution of city assets, population and economy.

With the extensive roll-out of the internet in the 1990s, more-and-more city systems became networked and reliant on computation and households started to become digitally connected. By the mid-to-late 1990s, urban theorists started to detail the nature of an emerging networked urbanism, wherein ICTs became increasingly critical to how cities and the activities within them functioned and were having profound effects on urban-regional restructuring by enabling pronounced space-time compression and the tempo-spatial reorganization of businesses and institutions (Castells 1996; Mitchell 1996; Graham and Marvin 2001). In the 2000s computation became ever more mobile with the rise of smartphones and other portable digital devices, and urban computation started to become pervasive, ubiquitous and instantaneous (that is, embedded into everything, available everywhere, and responsive in real-time) with increasing scales of economy in digital products, networking, and storage, and the rollout of the internet of things. At this point, many urban spaces were being produced as “code/spaces”; that is, the production of space was reliant on code to be produced as intended (Dodge and Kitchin 2005). By the late 2000s, the concept of ‘smart cities’ – cities that combine forms of entrepreneurial and networked urbanism – started to gain traction across city administrations, corporations and academic disciplines. Reconnecting with cybernetic thinking and aligning with the project of neoliberalism, smart urbanism envisages a thoroughly digital city in which city services, infrastructures and populations are managed in real-time using ICTs, yet at the same time digital technologies, such as smart phones, enable individual autonomy and consumption choice within a framework of constraints that prioritizes market-led solutions to urban issues (see Luque-Ayala and Marvin 2016; Cardullo and Kitchin 2017).

Over the past decade, accompanying the drive to create and deploy smart city technologies and visions, has been critical analyses of the tenets, workings and effects of smart urbanism. Building on critical scholarship concerning networked urbanism (e.g., Graham and Marvin 2002), such work has focused on mapping out the political economy of smart cities, how smart city technologies reconfigure urban spatiality, governance and development, and the ethical and moral implications of the production and use of urban big data (e.g., Greenfield 2013; Kitchin 2014; Vanolo 2014; Datta 2015; Shelton et al. 2015). To date, however, there has been little analysis of the temporal imperatives and effects of smart city technologies (though see de Waal 2013; de Lange in press; Leszczynski 2015; Coletta 2017; Coletta and Kitchin 2017; Datta 2017).

Smart city technologies produce a new timescape; that is, a set of associated temporal relations (time frames, temporality, pace, tempo, timings, sequencing, and time past, present and future) that work together to produce a particularized temporal landscape (Adam 2004). Smart city technologies and initiatives reconfigure the space-times and temporal rhythms and relations of cities, and re-imagine and utilise the past, present and future to drive smart urbanism. While smart city technologies have effects with respect to all four temporal modalities identified by Adam and Grove (2007) – 'past present', 'present present', 'future present' and 'present future' – the most critical to the logics and operations of smart urbanism, I propose, concerns 'present present' and the ability to be able to monitor, analyse and react in real-time. Indeed, the appeal and promise of smart cities is that they constitute 'real-time cities', composed of systems that work 24/7 and are reactive to unfolding events in order to optimize performance and gain efficiencies (Kitchin 2014). It is this temporal condition that the progressive development of smart urbanism outlined above has been striving to achieve through each iteration of innovation – the instantaneous control of space and spatial relations in real-time.

In this essay, I want to consider in some depth the notion of the 'real-time city'. The first section examines how smart city technologies seek to utilise real-time computation to transform urban management and governance and the pace, tempo and scheduling of everyday life. The second section considers the related temporalities of the real-time city (instantaneous time, timeless time, network time, machine time, chronoscopic time, code/spacetime) and unpacks the nature of "realtimeness" (Weltevrede et al. 2014) in the smart city, contending that ontologically and epistemologically real-time is relational, contingent and heterogeneous, with a diffuse set of realtimeness operating across systems, infrastructures and spatial media. The third section critically reflects on the implications of producing a real-time city and presents the case for asynchronous cities and an ethics of temporal dissonance. In sum, the essay seeks to strongly foreground time and temporality as a key lens through which to make sense of the impact of ICTs on urban life and encourage additional empirical and theoretical work.

2. The Real-time City

> "Imagine a world in which time seems to vanish and space seems completely malleable […] Where distance equals a microsecond in lapsed connection time. […] Almost all technology today is focused on compressing to zero the amount of time it takes to acquire and use information, to learn, to make decisions, to initiate action, to deploy resources, to innovate. When action and response are simultaneous, we are in real time"
> (McKenna 1997, 3-4).

> "[A smart city] is a city where you almost know in real-time what is happening. You can identify problems or bottlenecks in real-time and you can manage them and communicate back to citizens or various stakeholders the right information that helps them make better decisions"
> (City administrator, Dublin).

Heim (1993, 49) defines real-time as "simultaneity in the occurrence and registering of an event", with little to no latency in temporal duration. Increasingly we live in a world in which we expect real-time connection and response (see Figure 1). Indeed, people seem to have become fixated on knowing and taking part in the present – checking for new emails and responding, seeking out current news or weather, discovering when the next bus/train is due or avoiding congestion, browsing the newest posts on social media and commenting, being able to instantly connect with other people while on the move and to schedule meetings on-the-fly, being able to discover details about places close-by including opening times and reviews, and performing consumption on demand. Companies expect to be able to do business 24/7, to be able to access real-time data on their performance across different metrics, and to implement just-in-time production and delivery. And city administrations and utilities expect to be able to manage city services and infrastructures as they unfold, reacting to present conditions in order to optimize performance. For example, an intelligent transport system uses real-time data from cameras and sensors located across a road system, which are communicated back via telecommunications networks to a central hub for processing to regulate traffic light sequences in order to keep traffic flowing and minimize congestion. In many cases, the aim is not to simply be reactive but anticipatory, using present and past data to predict what will happen in the short-term (micro-seconds to a few months) and adapt system performance accordingly to head-off potentially negative outcomes. Such practices are known as nowcasting (Bańbura et al. 2010) and as well as being used in the management of infrastructures are central to activities such as predictive policing. Here, I want to consider in more detail how real-time technologies are transforming management and governance of city systems and the pace, tempo and scheduling of everyday life.

Fig. 1 – Real-time city

2.1 Management and Governance

For city administrations and utility infrastructure providers, smart city technologies offer the possibility of dynamically managing urban systems in real-time taking account of present conditions (Bleecker and Nova 2009; Kitchin 2014; de Lange in press; Luque-Ayala and Marvin 2016). Such systems seek to manage road, rail and water traffic, energy supply, telecommunication connections, safety and security, as well as monitor environmental conditions relating to the weather, noise and pollution. They work by continuously generating data about the performance of a system via networked sensors, actuators, transponders and cameras (the internet of things) that are fed back to a control room for human oversight or processing by an automated management system which can instantaneously handle and analyse data and respond as required. Such systems seek to monitor and maintain everyday "normal conditions" in order to create more efficient and optimized operations, but also to respond to exceptional circumstances providing instantaneous corrective actions before problems grow and multiply (de Lange in press; Kitchin et al. 2015). In all cases, there is an operational emphasis on maximizing the speed of monitoring and responding to events, and to managing in the present (Virilio 1997).

Real-time control rooms utilising SCADA have been in operation from the mid-twentieth century, but they have multiplied in number in the last couple of decades and have also changed in terms of how they operate.

Early control rooms were used to monitor and manage the performance of a closed system such as an electricity grid. More recently, their remit has been expanded to include more open and unbounded systems such as public spaces (CCTV, emergency management response) and transportation with multiple types of users/interactions (car, public transit, cyclists, pedestrians) (Luque-Ayala and Marvin 2016). In addition, the siloed nature of control rooms – that they generally concern the functions of a single domain such as electricity, water, security – has started to be broken down with the creation of more integrated, interoperable, and interagency control apparatus that provides a more holistic view of city operations. For example, the *Centro De Operacoes Prefeitura Do Río* in Rio de Janeiro is an integrative city operations and coordinated, emergency management centre that draws together into a single location real-time data streams from thirty two agencies and twelve private concessions (e.g., bus and electricity companies), including traffic and public transport, municipal and utility services, emergency and security services, weather feeds, information generated by employees and the public via social media, as well as administrative and statistical data (Kitchin 2014; Luque-Ayala and Marvin 2016). Increasingly, rather than being reliant on human decision-making, control rooms are becoming automated, with either humans-in-the-loop, wherein decision-making is automated but overseen by a human controller who can actively intervene, or humans-off-the-loop in which the system works in an entirely automated fashion (Docherty 2012). In the latter case, computation is used to monitor and regulate systems in wholly automated, automatic and autonomous ways (Dodge and Kitchin 2007). Such automation enables massive volumes of data from thousands of devices scattered across a city to be tracked and controlled in real-time that far exceeds the capacity of human attention. In other words, the control room enacts a form of algorithmic governance; what Dodge and Kitchin (2007) term "automated management". While the work of control rooms is largely hidden from direct public view, some of the data they process is being shared via publicly-facing dashboards, APIs, open data repositories, on-street dynamic signs, and radio bulletins, and plugged into mobile apps (Kitchin et al. 2015).

The power of control rooms is to actively manage the temporal rhythms of the city in the present and to enact new forms of governmentality. As Lefebvre (1992/2004) noted, cities consist of multiple intersecting rhythms and beats – traffic flow, timetables, work shifts, rush hours, night and day, and so on (see also Edensor 2010). These rhythms can be eurhythmic (harmonious and stable), isorhythmic (equal and in sync), and arrhythmic (out of sync and disruptive) (Conlon 2010). Urban life thus pulsates rhythmically, but not always harmoniously. Control rooms work to augment and regulate the rhythms of cities; "to limit arrhythmia and produce eurhythmic systems that maintain a refrain" (Coletta and Kitchin 2017, 3). In other words, the algorithms at the heart of the control room operations act as "algorhythms", seeking to produce consistent and desired rhythmic patterns (Miyazaki 2012). A traffic control room that processes real-time data generated by a dense network of sensors and cameras to sequence traffic lights works to algorhythmically synchronize the flow of vehicles (Coletta and Kitchin 2017). In such a system, the nature of governmentality (the logics, rationalities and techniques that render societies governable and enable government and other agencies to enact governance; Foucault 1991) shifts from a disciplinary form (in which people self-regulate behaviour based on the fear of surveillance and sanction) towards control (wherein people are corralled and compelled to act in certain ways) (Deleuze 1992). Control systems work by constantly modulating behaviour to act in a certain way within prescribed comportments; to be nudged and directed rather than self-disciplined (Braun 2014). In the case of the traffic system, the control room modulates the flow of vehicles across the network. This is not to say that such control is not negotiated, resisted and subverted, but that it is the govermentality logic at work.

2.2 Everyday Time-geographies

While real-time control rooms work to modulate and control behaviour, real-time mobile and locative media such as location-based social networking (e.g., Foursquare) and journey planner smartphone apps seek to provide flexibility and serendipity in individual time-geographies (Sutko and de Souza e Silva 2010; Evans 2015; Kitchin et al., 2017). Indeed, ICTs in general are having a number of temporal effects on the spatial practices and time geographies of everyday life (in a Hägerstrand (1970) sense of movement through time and space).

First, ICTs are facilitating an acceleration in the pace of activities and service delivery by enabling tasks to be undertaken more quickly, efficiently, and at a distance (obviating travel time and bypassing physical queues) (Virilio 1997; Rosa 2003). Undertaking activities in real-time, which previously would have taken time to respond, is illustrative of such acceleration. Second, the always-on nature of networked technologies and the availability of mobile access enables the "time shifting of activities to formerly unavailable time slots" (Crang 2007, 71). Time outside of work can be colonized by work-related activities and so-called "dead time" or "wasted time" endured during various forms of commute can be transformed into "productive time" (such as phoning, texting, emailing, searching information, sending files, and copyediting academic papers) (Lyons and Urry 2005; Wajcman 2008). Increasingly people then are becoming "always-everywhere available" (Green 2002), though they have also developed practices to manage such hyper-connectivity and changing patterns of activity (Lyons and Urry 2005). Third, ICTs increase the ability to multitask and to interleave activities so that several tasks can be performed simultaneously rather than sequentially (Crang 2007; Wajcman 2008). While ICTs facilitate such multitasking, nonetheless new practices and competencies have been developed to manage simultaneous and/or competing tasks and technologies (e.g. pagers and mobile phones) that can be used to interrupt and summon users (Licoppe 2010). In some cases, automation might take a task away all-together, freeing up time to undertake other activities.

Fourth, the temporal organization of activities is becoming more flexible and de-coupled from clock-time. Instant and mobile communication and the sharing of location information is altering coordination in space by enabling "perpetual contact" and on-the-fly scheduling of meetings (Katz and Aakhus 2002), and serendipitous encounters with nearby friends (Sutko and de Souza e Silva 2010). The scheduling and planning of activities and events thus shifts from planned actions at specific times and places to continual recalibration and reaction for any time, any place (Crang 2007). Spatial media have also enabled access to information about the real-time conditions of transportation networks, facilitating dynamic route planning; spatial search and location based services provide information on nearby businesses permitting contextual choice- and decision-making rather than advanced search and planning. Importantly, these tasks can be undertaken in situ, on-the-move and in real-time (Leszczyski 2015; Kitchin et al. 2017).

Fifth, instantaneous networked connections enable significant time-space distanciation, wherein activities are disembedded from local contexts and re-organized across large time-space distances (Giddens 1990). For example, labour might be organized across several global sites, with decisions made in one location, that may be in one time zone, affecting outcomes in another. Similarly places across the globe can experience shared moments (e.g., simultaneously watching a global sporting event or media story). Places are thus interdependent through dispersed sociotechnical systems that enable real-time interconnectivity.

Collectively, these shifts are producing 'faster' and more temporally flexible subjects, with urban life in the smart city becoming more frenetic, fragmented and lived in-the-moment (Adam 2004; Crang 2007; Hassan and Purser 2007). Indeed, the temporal organization of the city is increasingly being disconnected from the natural, social and clock time that operated in the late twentieth century. In addition, as Wajcman (2008) notes, smart city technologies do not simply speed-up or fragment time, but introduce new material, temporal and cultural practices. In other words, people are not simply "doing the same things, but at a faster pace", but are performing new kinds of tasks and producing new socio-spatial-temporal relations. As such, the temporal shifts occurring alter how we understand, relate to, move through, coordinate and communicate in, interact with, and build attachments to space/place (Kitchin et al. 2017). The real-time city then is not simply a faster city, but one whose spatiality, temporality and sociality have been fundamentally reconfigured.

3. Real-time Temporalities and Realtimeness

For philosophers of time, such as and Hassan (2003; also see Hassan and Purser 2007) and Virilio (1997), the changes to management, governance and the time-geographies of everyday life result from ICTs producing a new temporal modality. This modality is characterised by instantaneity and fragmentation and has been variously termed and described. For example, Hassan (2003) argues that ICTs produce what he terms "network time" – time fragmented and made simultaneous across globally connected digital networks. Network time is "globally networked rather than globally zoned. It is instantaneous rather than durational or causal. It is simultaneous rather than sequential" (Adam 2007, 1). People across the globe can share temporal alignments in play (online games) and work (online conferencing), organizing themselves temporally around their interactions rather than local clock-time. Hassan contends that just as the clock changed the meaning and experience of time by shifting the temporal organization of society from natural (e.g., seasons; diurnal cycles; body clocks) and social (e.g., religious events) registers, networked technologies are undermining the dominance of clock-time. Fixed meal times, pre-arranged meetings, social calendars, conventional working times (9am-5pm; weekdays/weekends) are being replaced by temporal flexibility and time shifting. For Urry (2000, 126-30) ICTs are producing what he calls "instantaneous time" – real-time, on-demand, at-a-distance, synchronous connection and response – which is having profound, complex and non-universalising spatiotemporal effects on social and economic life. Similarly, Castells (1996) argues that ICTs produce what he terms "timeless time", wherein localised clock-time is erased, suspended and transformed – "all expressions are either instantaneous or without predicable sequencing" (Castells 1998, 350) with networked systems being "simultaneously present" across time zones.

Likewise, Virilio (1997) contends that chronological time is being replaced with what he terms "chronoscopic time". Considering the ability to perceive and respond to distant events in real-time, such as 24/7 global media coverage of news and sports or communicating with co-workers located in different time-zones, he argues that audiences and workers have become accustomed to narrative time imploding (Purser 2002). Rather than unfolding successionally as before, during and after, or events being documented after the fact, people have become used to time being "perceived more in terms of abrupt and discontinuous irruptions of varying intensities"; to be focused on the real-time instant (Purser 2002, 162). 24/7 media coverage creates an eternal unfolding present of spatially and socio-politically disconnected snapshots, with instant rather than reflective analysis. Likewise, real-time control rooms and spatial media produce chronoscopic time in which cities and personal time-geographies are managed in the perpetual present, responding to emerging irruptions and serendipity.

Critical to this new temporality is the seeming annihilation of time and space by ICTs. Places can be instantly connected and actions can occur simultaneously across space (e.g., stock markets working in concert between time zones; networks of traffic lights concurrently being controlled based on present conditions; consumers buying goods or downloading online content). Urban life – shopping, communicating, banking, play, travelling, etc. – increasingly operates in a distributed "perpetual present" (de Lange, in press). This is the appeal and power of the real-time city – instant, always, and everywhere. Yet, what is the ontological nature of real-time?

What becomes clear when one examines real-time systems closely is that they are never quite in real-time, they always include latencies. This is apparent if one records a real-time stream of data, wherein it is clear that the data are sampled with a small latency between discrete data points (Mackenzie 1997). Moreover, this latency varies across systems rendering them asynchronous: "there exists instead an open-ended continuum within the network (…) measured in picoseconds upwards" (Hassan 2007, 50). In their comparison of different streaming social media and news platforms, Weltevrede et al. (2014) noted that each platform had variances in back-end processing and delivery of content, producing variances in their temporalities. When myself and Gavin McArdle examined the velocity of 26 types of urban big data it became clear that these data were temporally differentiated in two ways: how they were generated and how they were analysed, acted upon and shared (Kitchin and McArdle 2016). With respect to data generation, we categorized data as either "real-time constant" to denote data that are endlessly generated (e.g., a weather sensor that continuously records measurements), or "real-time sporadic" to denote data that are generated only at the point of use (e.g., clickstream data that is continually measured but only whilst a user is clicking through websites). In both cases, there is latency in data recording, with data being sampled every few milliseconds, or every ten seconds, or every five minutes, or whatever temporal rate the system had been programmed to perform. Similarly, with respect to data analysis and sharing in some cases as the data are recorded, analytics are performed, and the data published with only slight latency (e.g., as a tweet is tweeted it is recorded in Twitter's data architecture and micro-seconds later it is published into user timelines). In other cases, the data are sampled in real-time but their transmission, processing or publication is delayed (e.g., mobile LIDAR scanning by vehicles captures scans of streetscapes every second, but are stored on a local hard disk and transferred to a data centre at the end of each day) (Nokia 2015; Kitchin and McArdle 2016).

The temporal rate of data measurement and sharing is in part chosen and in part imposed. How a system is configured involves making decisions about balancing data resolution and noise (data quality) with respect to the task requirements against system configuration and performance (e.g., life of batteries, costs of data transmission/storage). The system components and architecture also affect temporality. All digital processing involves latencies related to memory buffering, CPU scheduling, and process interrupts, and visualizations are temporally framed by the "number of frames per second, or by refreshing cumulatively displayed information" (de Lange, in press). Similarly, different networking technologies (broadband, wifi, GSM, 3G, 4G, Bluetooth, Near-Field Communication) have different process rates and latencies. Computation for some tasks can take time to complete, even with high specification machines, due to the complexity and size of the endeavour. As Mackenzie (2007, 89-90) notes system performance and data recording is affected by the nature of device and network "machine time", including "seek time, run time, read time, access time, available time, real time, polynomial time, time division, time slicing, time sharing, time complexity, write time, processor time, hold time, execution time, compilation time, and cycle time". He continues, "[w]hile many of these are related (for example, read and write time), many are unrelated or antagonistic to each other (for example, real time, polynomial time)", noting that "[t]he relations between different timings are heterogeneous". In complex systems composed of many devices and networks (e.g., sensors, computers, routers, servers, etc) there are multiple machine times at play.

Mackenzie (1997) thus contends that real-time is a fabricated temporal condition, and Weltevrede et al. (2014, 127) conclude that there are varying forms of "realtimeness". This realtimeness produces distinct "real-time cultures" within platforms and systems. Weltevrede et al. (2014, 140-141) thus conclude that real-time "does not unfold as a flat, eternal now or as a global, high-paced stream, but (…) unfolds at different speeds in relation to different devices.". Moreover, realtimeness is provisional, always potentially subject to disruption through faults such as network outages and software crashes, and more malicious interventions such as hacking (Kitchin and Dodge 2011). The production of realtimeness has to be maintained through practices of upgrades, patching, and repairs in order for constant contact and action to occur. Even so, real-time systems often fail, with other modes of operation having to be deployed until the system is back online and working again. In case study research concerning the real-time operations used by a large retailer to manage stores, staff, stock, suppliers and customers, and to direct operations, Evans and Kitchin (2017) document how systemic system and equipment failures lead to partial and precarious real-time systems, with staff having to revert to old practices or invent new workaround solutions that often involve significant delay.

Realtimeness then is relational, heterogeneous and contingent; the product of the technicity of socio-technical arrangements and subject to all kinds of interruptions and contextual unfoldings. As such, there is a diffuse set of realtimeness operating within smart cities across infrastructures and spatial media (Kitchin and McArdle 2016), yet the nature of real-time across platforms and systems is little understood, as are their distinct real-time cultures and how they make a difference to the nature, experience and meaning of time, but also the culture, practices and institutional operations of everyday life. Similarly, the effects of realtimeness on the transduction of space is little understood. In terms of the smart city, my contention is that time and space unfold as code/spacetime (not simply code/space as I have previously theorised; Dodge and Kitchin 2005), wherein space-time relations are dependent on computation to function. For example, the algorhythms of a traffic control room seek to mediate the flow of traffic through junctions (sites) by altering the sequencing (timing) of traffic lights (Kitchin and Coletta 2017). If the code or computational infrastructure fails, then the realtimeness of the system is suspended, with the traffic lights either failing to work or operate on default settings; space-time is not transduced as intended. The realtimeness of smart city systems, and the code/spacetimes they transduce, work to create particular spatio-temporal rhythms and tempo, and facilitate new spatio-temporal relations and behaviours. As yet, however, we have little detailed understanding of how such realtimeness and code/spacetime work in practice both in a general sense and with respect to particular smart city technologies/domains (such as control rooms for utilities, real-time dashboards and passenger information, smart meters for energy management, sensor networks for monitoring sound/pollution/flooding, etc).

Given the drive to produce the real-time city, with ever-more aspects of everyday life computationally mediated and operating in real-time, there is a pressing need to critically unpack the nature and consequences of realtimeness. It is to the task of unpacking consequences I now turn.

4. The Case for Asynchronous Cities

A number of scholars have started to consider the implications and politics of real-time, arguing that a fixation on the present and speed of response creates a number of issues that need to be countered by the production of asynchronous smart cities. In essence, they challenge whether acting in real-time is always the right to time to act and consider the consequences of such responsiveness. There are four main, inter-related critiques, the first two of which concern the ability of individuals to manage and cope with thinking and acting in real-time, the second two with the nature of real-time governance and how societies are regulated. In all four cases, there is a sense that living and managing in the here-and-now overemphases the present at the expense of learning from the past and planning for the future (Bleeker and Nova 2009) and erases the frame of duration and trends (de Lange in press). Purser (2002, 160) goes as far as to contend that "[t]o think and act in real-time terms requires a certain kind of wilful blindness to the past and future."

First, the emphasis on speed and instant reaction means there is no time for reflection, contemplation, slow rational deliberation, considered answers, or affect and emotion in decision making and response (Purser 2002; de Lange in press). As Hassan (2007, 55) notes: "Users are compelled by the momentum of the now. Control in this context is almost impossible: take your time and you lose the sale, suffer a drop in efficiency, or miss the 'valuable' connection.". Compressed time for thought and action means that actors, such as urban infrastructure managers, have to fall back on either learned routines or established unconscious cognitive biases (Purser 2002), or come to rely on forms of automated management enacted through algorithmic systems (Coletta and Kitchin 2017). Family and friends become hustled into decisions and actions that they might not take if given time to reflect. Acting in real-time thus erodes choice and reflexive and meaningful action and limits alternative and creative intervention (Leccardi 2007). In other words, *kairos* (the right time to act judiciously) is trumped by *chronos* (action with respect to the measure of a clock).

Second, the demands of living and acting in real-time – of always being connected and cognitively engaged through email, mobile phones, social and spatial media, etc. – creates a temporal regime that compels never-ending engagement, and produces stress through increased demands on peoples' time and attention, with few opportunities to disengage and relax (Gleick 1999). As Crang (2007) details, while ICTs hold the promise of helping people cope with the compression, densification and fragmentation of time by actively managing "temporal density" (intense, overlapping temporal rhythms caused by multitasking) (Southerton and Tomlinson 2006) and "time scarcity" (the experience of being rushed or harried) (Wajcman 2008), at the same time they compress and fragment time further. ICTs often produce ever-more-extended and complex network of tasks to attend to, producing time crunches in which it never feels there are enough hours in the day to do all the things needed (Hassan 2007).

Third, the reliance on algorithmic systems to process and respond to real-time data creates forms of technocratic governance in which an intense instrumental rationality (that is reductionist and functionalist in approach) and technological solutionism (that presumes that complex urban situations can be solved or optimized through computation) are applied (Kitchin 2014; Mattern 2014). Such an approach prioritizes optimization, efficiency and rational decision-making as the key bases on which to manage and improve urban living (Bleecker and Nova 2009) and assumes that the same technological solutions can be easily transplanted between cities to produce similar effects (Kitchin 2014). Such solutionism tends to map events in isolation, reducing them to singularities in which systems identify and respond to out-of-the-ordinary occurrences so that dealing with the exceptional becomes routinized (de Lange, in press). In other words, managing the city in real-time creates a disengaged, decontextualized, rote, rule-based approach that lacks reflection, deliberation, communal debate, learning trajectory, and framing to local socio-spatial-temporal conditions beyond instrumented metrics. They thus fail to take account of the wider effects of culture, politics, policy, governance and capital that shape city life and how it unfolds (Kitchin 2014; de Lange, in press). Moreover, they tend to manage issues in instrumental ways rather than addressing their underlying structural causes; that is, a traffic control room seeks to optimize flow and minimize congestion, rather than shifting people from private vehicles to public transport. As Bleecker and Nova (2009), Greenfield (2013) and others have argued, part of the appeal of cities is their messy, emergent, qualitative experiences, their anonymity, serendipitous encounters, and the unexpected. The "hygienist model of efficiency" (Bleecker and Nova 2009) – the desire to assert order and control – thus does structural violence to what we might call 'cityness'. In so doing, technocratic forms of governance run counter to democratic politics, with real-time computationally-mediated management excluding meaningful public participation in governance, bypassing the creative, political and messy role of people in shaping their own environments. As de Lange (in press) concludes:

> Creativity, always asynchronous and unpredictable in comparison to computerized systems, becomes ballast rather than a resource. Unless they allow room for differential tempi of people using them, real-time technologies that aspire to infinitely speed up their own working quite literally preclude the latent potential of people to use these technologies for truly democratic collective self-mastery, governance and creation.

Fourth, the immediate actions of the present create a recursive, iterative path dependency for the future with decisions taken shaping a system's imminent performance (Uprichard 2012). Moreover, as Uprichard (2012, 133) notes, the aim is often not simply to know now, but "to know about now before now has happened". Algorithmic and technocratic governance thus works to prefigure, through pre-determined, programmed responses and feedback loops, the unfolding of socio-spatial-temporal life. This is leading, she contends, to the present being increasingly embedded into institutional structures and vice versa, with the result that the "present itself becomes more and more plastic, to be stretched, manipulated, moulded and ultimately 'casted' by those who can access more of it in the supposed 'now'." From this perspective, urban control rooms cast the present by iteratively pre-figuring it through on-going responses. The consequence of always living in the now, Uprichard (2012, 134) argues, is we will increasingly "cut our coats according to our present cloths", becoming rooted in a constant series of "plastic presents" that limit the possibilities of alternate emergent futures and largely ignores the past or the future present.

For Virilio (1997, 19) there is thus an emerging "tyranny of real time", a "dromospheric pollution" (*dromos* being the Greek for race, which Virilio associates with speed/acceleration) in which the temporal demands of real-time exceed our capacity to cope with them and take effective action (Purser 2002). Moreover, real-time smart city systems produce the condition of continuous geosurveillance, in which spaces and individual mobility are monitored at fine-grained temporal and spatial scales, enabling a detailed tracking and tracing of people, objects, transactions and interactions, and producing numerous privacy harms (Kitchin 2016). Real-time systems produce a smart city then in as far as they seek to provide stability and control in urban governance by reacting to unfolding situations, albeit in a limited, technocratic means, but they do not necessarily produce greater understanding or forms of smart citizenship (Kitchin 2014; de Lange in press).

For some, the fixation on operating in real-time needs to be countered by maintaining asynochronicity in the smart city. Leccardi (2007), for example, calls for an opposition to the "detemporalized" logics of a real-time present and for a reappraisal of the value of the lived dimensions of time and space and the connections between the past and present. Hassan (2007, 46) likewise calls for people to be able to have more control over their time and to be able to "refuse to be swept up into the acceleration of society and the time-squeeze that is taking its toll on cultures and societies". Just as the continuous geosurveillance of IoT needs to be tempered by an ethics of forgetting (Dodge and Kitchin 2007), the tyranny of real-time requires an ethics of temporal dissonance. For de Lange (in press) asynchronicity would enable citizens to live in the city at their own pace, not just slowing down but operating at differential speeds. Bleecker and Nova (2009, 19) contend that such an aspiration requires urban computing to be citizen-focused and not simply about operational efficiency and optimization, concluding "computing in an urban setting should first of all not be about data and algorithms, but people and their activities". They venture that real-time computation should have layers or routines that do not work instantaneously, are out of alignment and incongruous or decentralised, and are more speculative, poetic and unexpected. Real-time systems configured in such a way would produce lively cities, not simply ordered, optimized ones.

While such calls for temporal dissonance and asynchronous temporal relations may seem appropriate given the growing use of real-time systems and their consequences, as Adam (2004) and Crang (2007) note, urban life remains lively. In fact, temporal relations are being reconfigured not annihilated (Crang 2007), with "instantaneity, simultaneity, networked connections, ephemerality, volatility, [and] uncertainty" running alongside and being superimposed on "linearity, spatiality, invariability, clarity and precision" to create new "temporal multiplicity and complexity" (Adam 2004, 65). The result is that people find themselves enmeshed in several competing temporalities simultaneously. For example, a person heading to a meeting at 10am, using their mobile phone to talk to a colleague on the other side of the planet while waiting at a pedestrian crossing for the network-controlled traffic lights to change is negotiating global time and local time, clock time and network time, as well as social and natural time. She is experiencing pronounced time-space distanciation of a long-distance call, as well as very localised time-space choreographies of negotiating an intersection; both chronoscopic and chronological time. For Crang (2007, 70) then people are negotiating a complex "chronotopia" of varying pace, tempos, rhythms, scheduling, temporal relations and modalities, and these are contingent for different people in different places. The trend towards real-time does have consequences with respect to governance and individual time geographies that require reflection and attention, but the emphasis of critique should be on the maintenance, rather than recovery, of asynchronous and lively cities.

5. Conclusions

Smart city initiatives reconfigure both space and time. In this essay, I have concentrated on examining how temporality is being modulated, focusing on the drive to create real-time cities. Increasingly, urban management is being operated in a perpetual present, with present conditions prefiguring an immediate reaction, and urban life is gaining speed, tempo and temporal flexibility. As I have illustrated, real-time is relational, heterogeneous and contingent, taking different forms across platforms and systems due to varying configurations and operations of machine time. As a result, multiple cultures of realtimeness unfold and these intersect in practice with other temporalities to produce complex chronotopias. However, while operating in real-time has a number of advantages, particularly with respect to responsiveness, efficiency, optimisation and flexibility, it also raises a number of concerns regarding the formulation and practice of governance, the compression and fragmentation of time, and how these impact on individuals, society and economy. To date, however, there has been relatively little critical scholarship on the nature of real-time and its implications with respect to different domains. While I and others have started to fill this lacuna with some initial reflections, much more research and critical analysis – philosophical, theoretical, and empirical – is required to consider several questions concerning the real-time city. There are many avenues for such studies and reflection, but I propose concentrating on four related concerns.

First, there needs to be sustained consideration of the ontology and epistemology of real-time and realtimeness. What is the nature of real-time and realtimeness? How do we best make sense of real-time and realtimeness; to understand and explain theoretically the relations of time, technology and the city? I have posited that real-time is relational, heterogeneous, contingent and provisional, with systems exhibiting varied realtimeness that produce chronotopias and almost but not quite real-time cities; what are plausible alternative conceptions? Also, how should the dimensions of realtimeness be measured? As I have detailed elsewhere with respect to researching the nature and work of algorithms, unpacking the workings of code and computational machines is often tricky to perform (Kitchin 2017). Digital systems are often black-boxed and proprietary, they are heterogeneous and embedded, and they are ontogenetic, being performative, contingent, and mutable. Figuring out the elements of machine time and their broader configuring within social-technical assemblages, as well as how they unfold in practice, is far from straightforward.

Second, there needs to be a systemic analysis of the relationship between real-time ICTs and individual time-geographies, modes of governmentality, and the production of chronotopias. How does the cultures of realtimeness of specific platforms and systems intersect with other temporalities to produce chronotopias? How do those chronotopias unfold in practice and to what extent are they shaped by social relations (gender, sexuality, race, ethnicity, disability, class, caring responsibilities, etc.)? What are the implications of these chronotopias for individual time-space trajectories and for how institutions (e.g., employers) and social structures (e.g., families) organize and regulate time? In what ways does real-time monitoring and response transform regimes of governmentality and what are the implications for city administrations and citizens? In what ways does a prioritisation of acting in real-time alter the ways in which the past, present and future shape social relations? As noted in the essay, there is now a fair body of work that examines such questions with respect to mobile and spatial media, but our understanding is still evolving and advances in technologies produce new, emerging practices and phenomena.

Third, the relationship between realtimeness and space/spatiality needs to be examined and theorised. How does the adoption of real-time platforms and systems affect the experience and meaning of time and space in the contemporary city? How does realtimeness intersect with the transduction of space? Do real-time platforms and systems inherently transduce code/spacetimes? How do code/spacetimes unfold contingently, relationally and contextually with respect to particular smart city technologies and domains (home, work, retail, public spaces, etc.) and practices (governance, mobility, consumption, production, etc.)? In this essay, I have primarily been concerned with exploring the temporality of the real-time city, largely placing the role of space to one side. However, time and space are clearly interdependent, whether that is *chronos* and *choros* (clock time and geometric space) or *kairos* and *topos* (social time and lived place), or *chronos/topos*, or *kairos/choros* (Sui 2012). Indeed, some theorists would posit that time and space are so thoroughly entwined that they operate as a fused dyad – timespace (May and Thrift 2002); in other words, it is impossible to separate time and space into co-productions (time-space) or consider them as separate phenomenon that instigate discrete processes (time and space). From this perspective what are the real-timespaces of cities and what are their tempospatial implications?

Fourth, the politics and ethics of real-time needs to be unpacked, a normative exploration of realtimeness conducted, and consideration given to the resistance and subversion of dromospheric pollution. As detailed in the third part of the essay, operating in an 'eternal now' and 'perpetual contact' produces a set of challenges both with respect to the unfolding of individual time geographies and the practices of governmentality. Speed, efficiency, optimisation, interconnection, and automation are prioritised as virtuous tempo-spatial relations, and *téchne* (instrumental knowledge) is prioritised over *phronesis* (knowledge derived from practice and deliberation) and *metis* (knowledge based on experience) (Parsons 2004; Kitchin et al. 2015). There is thus a politics and ethics in adopting real-time technologies as it prioritises particular values and knowledges, which then have consequences to how urban life is experienced and cities governed. As others have started to argue, there is merit in a counterview of valuing asynchronicity; of valuing *kairos* over *chronos*. As yet, however, an ethics of temporal dissonance, such as the notion of "slow computing" (Fraser 2017), has barely been articulated. Similarly, the ways in which individuals and communities are resisting realtimeness and seeking to act in alternative temporalities are little documented. And we have hardly considered from a normative perspective what kind of real-time city we want to create and live in?

As networked ICTs become increasingly embedded into the fabric and workings of urban systems and everyday living, we will increasing reside, work and play in the real-time city and experience realtimeness. It is imperative then, I believe, to address the questions I have set out above, implementing a series of empirical and theoretical projects that examine in detail the configuration, operation and consequences of real-time systems and the changing tempo-spatiality of smart cities. In so doing, we will start to flesh out the nature, politics and ethics of realtimeness, and produce strategies to ameliorate some of the negative consequences of operating ever-more in the here-and-now; to produce real-time cities that balance *chronos* and *kairos*.

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Ordinary Smart Cities
How Calculated Users, Professional Citizens, Technology Companies and City Administrations Engage in a More-than-digital Politics

Ignacio Farías
University of Munich (DE)

Sarah Widmer
University of Munich (DE)

Abstract: The 'smart city' is likely one of the most unbearable current policy discourses and frameworks not just due to its technological determinism. Hence we are interested in exploring alternative narratives on 'smart cities' by proposing two main 'moves' from conventional perspectives. The first one involves considering a wider range of actors and logics than those usually considered in descriptions of smart cities. This does not just imply paying attention to grassroots organizations and private tech companies that develop data-driven urban services outside the conventional smart city programs run by municipalities, but also taking seriously the various non-digital logics and concerns that articulate or collide with smart city projects. The second move directly derives from the first one, as it proposes to go from a narrow focus on smart governmentality to a broader understanding on the (cosmo)-politics of smart urbanism. We examine these moves in the light of two quite different instances of smart urbanism: a service for urban exploration offered by the tech company Foursquare and a smart city project implemented by the municipality of Munich. Following the political trajectories of these two cases of smart urbanism, we underline the more-than-governmental and more-than digital logics that intervene in the making of 'ordinary' smart cities.

Keywords: smart urbanism; (cosmo)politics; users; post-demographics; citizens.

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Corresponding author: Ignacio Farías, Department of Architecture & Munich Center for Technology in Society, Technical University of Munich, Germany. Email: ignacio.farias@tum.de

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1. Decentering the Smart City

For both science and technology studies (STS) and urban studies scholars the 'smart city' is likely one of the most unbearable current policy discourses and frameworks. The technological determinism infusing the celebration and critique of 'smart' device infrastructures is almost as naïve and problematic as the knowledge claims of the so called 'new urban science'. What makes these issues unbearable is a combination of their ubiquity (the fact that we are constantly forced to relate to them) and their simplicity (the fact that these are not very good problems to think with). It seems that we could continue to write many articles and books taking apart the idea of the smart city without arriving at new and interesting propositions. So it cannot be overstated that there is an imperative need to turn our attention to what Shelton and colleagues have suitably called "the actually existing smart cities" (2015). As these authors argue, "the assemblage of actors, ideologies and technologies associated with smart city interventions bears little resemblance to the marketing rhetoric and planning documents of emblematic, greenfield smart cities, such as Masdar in the United Arab Emirates, Songdo in South Korea, and Living PlanIT Valley in Portugal" (2015, 14). The challenge then is to ground the smart city in the historical and geographical context in which it is being implemented and thereby to provincialize it (Datta, 2015), to counteract the figure of the "smart city as a kind of universal, rational and depoliticized project that largely plays out according to the terms of profit-maximizing, multinational technology companies." (Shelton et al. 2015, 14).

But how to do this? In this lecture, we would like to propose two analytical moves for rendering the smart city into a more generative research problem: firstly, decoupling the problem of smart city from the problem of data-driven cities and, secondly, expanding the focus from governmentality issues to a broader exploration of the (cosmo)-politics of the smart city. Let us briefly explain these two moves.

Firstly, uncoupling the analysis of the smart city urban development from the capacity of big data analytics to govern urban life is crucial, for some of the most interesting data-related developments and reconfigurations are not occurring under the smart city projects and strategies run by cities. Shelton et al. observe that "it is important to note that the smart city as it has largely been envisioned and critiqued bears little resemblance to the reality of how urban planning and governance is changing in the era of big data" (2015, 15). Accordingly, in order to understand what the smart city of the future might look like, we might need to look at actors, collectives and companies that are not necessarily part of the "new inter-organizational partnerships and alliances, built around the development and implementation of data-driven governance projects" (Shelton et al. 2015, 16). Tironi and Sánchez Criado (2016, 97) point for example to the importance of looking at "digitally -mediated sensing practices developed in grassroots projects that have emerged alongside, but also intersecting and opposing, *smart city* projects" and the extent to which "'alternative' projects may provide concerned parties with instruments to slow down, avoid the pitfalls of either praise or criticism, and learn how to build more interesting relations to what the ongoing digitalization of the urban might bring" (2016, 98). By the same token, we need to also consider corporate products and services such as Pokemon Go and Foursquare, a case we will discuss in detail, as they enable new ways of relating to and discovering the built environment, albeit by no means integrated in any smart city initiative whatsoever.

By the same coin we need to challenge the idea that the data-driven city would be a good descriptor of the new modes of urbanization that are currently being unfolded around the notion of the smart city. As Shelton et al. have pointed out: "while data is both the driving force behind smart city initiatives, as well as the means by which these initiatives are implemented, the ultimate goal of the policies is fostering economic development, with success judged accordingly. Thus, [...] the smart city idea largely coalesces around strategies for economic growth in an era of austerity" (2015, 16). A good example of this is the Horizon 2020 Program for Smart Cities and Communities, whose explicit aim is not just to facilitate the implementation of smart technologies that lead to the reduction of carbon emissions but to invest in the development of business models for global smart city markets, thus attracting money and jobs to Europe. Discussing a current project funded under this scheme, it will become apparent that smart city projects are rarely shaping the strategies of urban development and they are pursued alongside many other urban development programs. Cities are indeed multiple objects, where different forms of governing, knowing, valuing and practicing the city interact and enter in conflict with each other. In that sense, it seems crucial to go beyond the figure of a data-driven city which would not reflect upon the ways in which smart city assemblages interact with other incommensurable ways of enacting and living the city, to a broader understanding of the politics of smart urbanization in order to encompass both the data-driven government of urban life and, perhaps most importantly, conflicts about the very production of data.

Secondly, we need to go from a focus on the power of smart technologies and on the smart city as a governmental data-driven apparatus to a broader understanding of the politics of the smart city. Most of the literature has been concerned with the types of urban citizens and populations constituted through data-driven and smart technologies. Contributions of leading authors have notably discussed the smart city along the lines of disciplinary and security technologies, rationalities and power formations. Whereas Vanolo (2013) reads smart urbanism as a disciplinary urban development paradigm, Klauser et al. (2014) discuss, under the notion of "governing through code", how smart electricity projects seek to optimize a "relationally composed whole" (p. 873) not based on an *a priori* norm with which singular elements have to comply, but letting things happen within the limits of the acceptable. Klauser et al. thus address the flexible and adaptive logics of data-driven and automated governmental securitization. The recent work of Gabrys (2016) places the smart city in a larger power formation involving what she calls planetary computerization and involving new forms of governmental action "performed through environments that are computationally programmed" (2016, 187). Drawing on Foucault's late reflections on biopolitics and his interest in milieus and environments as objects of government, she frames the power logics of urban participatory sensing around the notions of 'environmentality' and 'biopolitics 2.0'.

Despite the incontestable value of these works, we think that it is necessary to broaden the analytical scope to explore the cosmo-politics of smart cities, and not just to their governmentalities. As Rancière, Latour and Foucault would agree, the notion of politics describes a different relation to power than government. The latter, as Foucault has brilliantly argued, is about the conduct of conducts and relates to the historic formation of power concerned with the securitization of populations and the practices of the state. In Rancière's terms (2009), government corresponds rather with the policing of institutionalized distributions of the sensible. Be that as it may, the important point here is that studying the smart city in terms of its governmental arrangement is at odds with an exploration of its politics in the Rancierian sense, namely the conflicts, controversies and disruptions entailing the possibility of a redistribution of the sensible or, as Bruno Latour would have it: a (cosmo)political practice aimed at the progressive composition of the cosmos we live by. Such redistributions and recompositions do not just occur through the sudden irruption of the 'part that has no part', but are actually unfolded in spatio-temporal trajectories enacting different 'political modalities' (Latour 2007), of which governmentality corresponds to only one.

Indeed, Latour proposes the redefinition of politics as cosmopolitics in order to grasp the (contested) composition of common worlds. Drawing on De Vries's study of the history of maternal blood screening in the Netherlands, Latour charts the various meanings that the adjective 'political' can take in such contested processes, redefining who we are and how we live. He identifies five key stages and meanings of the political. Political-1 stands for the stage in which new associations between humans and nonhumans are made; a political moment typically detected by STS scholars studying technoscientific innovations. Political-2 stands for the moment in which the new association (or issue) formed in stage-1 has consequences that entangle a public of unanticipated actors around it (a moment that pragmatists, and Dewey in particular, have detected with their focus on the public and its problems). Political-3 corresponds to the moment in which the machinery of government tries to turn the issue into a clearly articulated question of common good (the political as framed by political scientists studying the question of sovereignty). The next interval on the trajectory of an issue is political-4, defined by Latour as the Habermasian moment, in which the issue is debated in a deliberative assemblies. The final stage, political-5, is labelled as 'governmentality' and corresponds to the moment in which the issue has become naturalized to the point that it is taken for granted and appears as completely apolitical[1].

Latour's (cosmo)political framework is helpful to empirically follow the different types of issues unfolding around the smart/data-driven city and thus expand the narratives and stories we tell about it by including the various actors and non-digital logics with which smart and data-driven urban projects articulate or collide. In what follows, we will refer to Latour's framework when considering the political trajectories of two rather distinct case studies which are representative of actually existing smart cities. First, we will tell the story of the smartphone application Foursquare and reflect about its post-demographic mode of constituting individual users as crowds, where the power formation is not governmental but aims at the capitalization of user data. Secondly, we will look at the implementation of the project Smarter Together in Munich and, by focusing on the various negotiations surrounding the instalment of data infrastructures, we will demonstrate how such high-tech, computational projects are to a great extent shaped by and plagued by sovereignty concerns. We will conclude with a short summary and a final reflection about how these stories allow us to go beyond the analysis of data as a driving force of smart urbanism.

2. Foursquare: The Subtle Politics of Post-Demographic Data-Intensive Urban Services

The first case we examine in order to address the political trajectories of the 'data-driven city' is the case of Foursquare, a local search-and-discovery mobile application providing personalized recommendations on places to go to (bars, cafés, restaurants, etc.). By showing how a private tech company orchestrates the consumption of urban amenities, we depart from the common emphasis on the smart city as an urban development strategy led by city administrations and stress how cities are being transformed today in uncoordinated ways by multiple private corporations offering very specific smart urban services.

Launched in 2009, Foursquare began as a location-based game and social network but morphed, from 2011 on, into a local search application

[1] It is certainly rather strange that Latour equates governmentality with that which remains uncontested and appears as apolitical in a certain time and that he makes no reference whatsoever to populations, security, biopolitics or neoliberalism, the key conceptual markers of what Foucault describes as governmentality. Indeed, what Latour frames as political-5 corresponds rather to what Foucault more generally describes as a historical formation of power, be it based on sovereignty, discipline or governmentality.

allowing users to find bars, coffee shops and restaurants in their surroundings. The functioning of this search-and-discovery engine relies on the production of data by users. This data (mostly locational data) is used to profile users and make targeted recommendations. Until the big revision of the app in 2014, users generated locational data by 'checking-in' to places, i.e. by indicating on the app their presence in a specific venue. Since the 2014 revision, people are not required to check-in any more, as their presence is automatically detected by 'Pilgrim', a technology running in the background of the app, sensing where the user goes and stops and finding the corresponding venue in the huge database of places constituted throughout the years by the company. The changes which occurred in 2011 and 2014 are critical to understand the app's main service (to provide users with personalized recommendations on nearby places) as well as to grasp the way in which it constitutes, knows, and eventually exploits its users. Certainly, Foursquare and its functioning through profiling are not 'overtly' political. Its political dimension lies with the ways in which it assembles different actors (users, data, software developers, algorithms, urban places) and constitutes 'users' through data and algorithmic calculations in data-driven and calculated ways. It involves the kind of new associations of humans and nonhumans that Latour describes as politics-1.

Notably, when Foursquare's engineers first developed their recommendation tool in 2011, they interpreted locational data as a reflection of what the user liked in terms of food, ambiances, neighborhoods and types of places. In other words, the history of check-ins of a user was used to create a knowable 'subject of tastes', for whom targeted recommendations could be formulated. Although check-ins had not been conceived in the first place as indicators of tastes (they initially served the gaming purpose of collecting badges and mayorships), Foursquare's engineers favored this specific understanding of the data; an understanding that assumed the existence of a univocal user whose production of locational data reflected her elective affinities. Check-ins were in reality equivocal, entailing fundamentally different types of attachments to places, practices of producing data and curating a 'locational self' on the platform. The digital histories of users were sometimes composed of fake check-ins, check-ins to bus stops and to other places hardly indicative of their tastes. It is reasonable to believe that the new version of Foursquare, launched in 2014, involved an attempt to fix the messiness and polysemy of check-ins by automatizing the production of location data through Pilgrim. At this point, users come to be constituted through the association between their own check-in practices, the decision of the developers to use check-ins as proxies for tastes but also by the types of amenities offered by the city or the neighborhoods in which the user spends her time. Foursquare is also 'calculating' each user by finding similar patterns between their digital history and those of other users. More precisely, Explore (Foursquare's recommendation engine prior to the 2014 revision) operated by finding patterns in two types of networks: what the developers called the 'place graph' and the 'social graph'.

The 'place graph' is about the ways in which places are connected together through the data produced by users. Patterns of locational data reveal different types of connections between places. For instance, by identifying the sequence in which users checked-in from one place to another, it is possible to spot 'flow relations' i.e. the tendency of one place to be visited after another. Relations of 'co-visitation' exist among places that are visited by the same sets of users. Relations of 'category' refer to the relations between places of same function or activity e.g. sushi restaurants or hair studios. The so-called 'social graph' (based on the origins of Foursquare as a social network) consists in analyzing how users are connected on the app via different kinds of interactions. At the time of Explore, they could 'friend' each other, 'follow' the accounts of specific brands or save or like the tips and comments left by other users on a certain venue. Another very powerful 'social signal' was the 'co-location' of users, or to put it differently, their tendency to visit the same physical places (Shaw 2013).

Calculating relations of 'flow', 'co-visitation', 'category', 'friendship' and 'co-location' are fundamental operations for Foursquare to provide relevant recommendations to each user. Importantly, a series of assumptions underpinned such calculations: 'the places that your friends like are good predictions about the places you might like as well', 'the places visited by people with similar check-ins habits than you might also interest you', 'you went to a lot of sushi restaurants, you probably want to discover some new ones' etc. The assumptions of the app developers on what constituted relevant recommendations were translated into specific calculations and shaping a 'calculated user'. Based on these assumptions and calculations, Explore was creating highly personalized and dynamic maps. Personalized, because they were drawing on each user's own digital history and were calculating those connections for each one of these 'calculated users'. Dynamic, because Explore was not only adapting its recommendations to changing contexts of use (i.e. locations, time of the day) but also taking into consideration the ever-evolving nature of these calculated users, who were constantly posting new check-ins, writing new comments and 'friending' new users thereby creating or consolidating new relations in the place and social graphs (Klauser and Widmer, 2017).

The question we would like to pose here, in reference to Latour's political-5, is: if Foursquare wields a certain form of power capable of constituting users and shaping their spatial and social relationships, to what kind of power formation does it amount?

Interestingly, neither disciplinary normalization nor governmental securitization, as they have been discussed for smart/data-driven cities, are useful to understand the power formation articulated by Foursquare. Indeed, even though individual subjects are the ones whose actions are targeted here, Foursquare is not a disciplinary device. It does not "regulate [...] everything and allow […] nothing to escape" (Foucault 2007, 67) but builds upon a power of suggestion, sparking the desires and attachments of users by affording rewards and incentives as well as a personal service.

Foursquare works as an ‘attachment device’ (Cochoy 2017), whose action on the ‘field of possibilities’ of users (Foucault 1982, 790) cannot be described as ‘subjugation’ or ‘normalization’. On Foursquare there is no pre-given norm to which subjects are expected to conform, as in the case with its main competitor, the application Yelp, which is based on a calculation of users’ reliability and then defines these reliable users as the norm to follow. On Foursquare, recommendations are aimed to fit the user’s calculated tastes. Thus, not only has every user the opportunity to be a norm of their own, but the norm itself is constantly fluctuating as newly volunteered data is added to the system.

Notably, even though Klauser et al. (2015) rightly point to these fluid and flexible norms adapting to the ‘reality’ of data as characteristic of a governmental form of power, the case of Foursquare is different, for the app does not aim at governing a population or securing the conditions of its reproduction. This is not to say that populations are irrelevant. The functioning of the app is based on the crowd-sourcing of data and the calculation of similarities among ‘populations’ of users. In order for Foursquare to target the individual user it has to find statistically significant relations of co-location, co-visitation, flow, etc. in the mass of user-generated data. Indeed, when a user could not be algorithmically connected to a sub-population of like-minded people it became more complicated for Foursquare to govern this user as a ‘unique’ subject, bearer of her own norm. In that case, the user would receive less targeted content and more one-size-fits-all recommendations for places considered popular.

So what type of power formation does Foursquare articulate? Is it security in disguise, as the fluid, centrifugal and open aspects of these data-driven regulations seem to indicate? Or are these specific modes of shaping individuals and populations delineating a new apparatus of power? Rather than delineating a brand-new power apparatus, we would like to stress two key aspects of the data-driven power formations of services like Foursquare.

The first aspect to stress is the post-demographic form of such data-driven power formation; a feature that has been discussed in recent literature. As Ruppert observes, in data-intensive environments subjects are increasingly known “not so much in relation to pre-defined categories of identity [such as age, gender, place of residence, education etc.] but in relation to what people do, their interactions, transactions, performance, activities and movements” (2012, 119). Notably, her study of the governmental practices of child welfare agencies, as well as Mackenzie’s (2016) analysis of the individual targeting of electors during Obama’s re-election campaign, describe a new type of relationship between subject and population. In Ruppert’s example children potentially at risk are targeted through the joining-up of different databases. In the case studied by Mackenzie, every voter in the country was assigned a score, recalculated every week according to new events (such as Sarah Palin’s vice-presidential nomination or the collapse of Lehman Brothers) and targeted accordingly by Obama's campaign crew (Issenberg 2012). In both examples, the fine-grained data obtained on people allow for the targeting of singularities (individuals identified as potential swing-voters or children at risk) instead of multiplicities (socio-demographic groups). Interestingly, both authors propose understanding the subjects constituted and targeted in such data environments as 'monads'. Ruppert (2012, 127) writes that joined up databases materialize the subject as "a monad made up of complex, unique, dynamic and always varying metrics", while Mackenzie (2016, 116) describes how electors are "distributed across varied populations of different kinds that intersect through them" and how, by attracting probability distributions, these individuals themselves become populations or crowds.

Such a description of a post-demographic form of power fits very well the case of Foursquare as a recommendation service not based on socio-demographic characteristics of individuals and groups, but on dynamic patterns, relations and regularities in the data. Foursquare performs each of its users as the relational effect of an ego-centric population but, as we have described above, the main difference is that it is not the government of a specific population, voters or children at risk, that is primarily at stake.

Thus we come to the second key aspect we would like to stress here. If it is not about governing users by post-demographic means, then what is what Foursquare does to its users? To approach this question, it is helpful to understand the business model of Foursquare. Notably, although the services offered by Foursquare have been around for some years now, the app never encountered the outstanding success of a Twitter, a Facebook or a Snapchat. The services provided by the company have always remained a niche and, facing competitors such as Yelp or Google Maps, Foursquare never became the 'killer app'. The difficulties encountered by the company became obvious when, during the funding round of 2016, its financial value was cut by half in comparison to what investors thought it was worth in 2014. Despite these difficulties, the company is still standing, and its survival is certainly due to the immense amount of data it has gathered throughout the years. By collecting location data from its users, Foursquare has constituted a huge geo-referenced database of places which has enabled it to become a "pillar of the mobile app ecosystem" (Barouch 2013) by providing its API to other developers. Recently, the executive committee of Foursquare decided more explicitly to exploit the financial value of this data, by monetizing access to the API and by creating the platform 'enterprise.foursquare.com', on which different services based on Foursquare's 'locational intelligence' are proposed to other companies.

If 'data is the new oil' it is, without a doubt, the oil of Foursquare. Data thus becomes not just the driver of urban life, or of people's engagement with urban amenities, but it constitutes the most important asset for securing the very existence and economic success of the company. The power formation that Foursquare articulates is one in which what needs to be defended and secured is not a collective concern that requires a governmental form of action but the profitability of the company. The economic value of data sheds new light on the key subject constituted by Foursquare: the producer of this data, the 'user'. The story we have told demonstrates the complex arrangements developed to constitute this subject but we would miss the point if we conceived the user solely as a consumer of the company's smart service for urban exploration. The user as the producer of data is indeed the main resource exploited in its business model.

3. Smarter Together: On Sovereignty, *Berufbürger* and the Politics of Translation

How else does the politics of smart cities unfold in the contemporary context? The second story we would like to present concerns the implementation of the project Smarter Together in the area of Neuaubing-Westkreuz in the city of Munich; a project funded by the EU-Horizon 2020 program Smart Communities and Cities aimed at funding consortiums of cities with a common smart city CO2-reduction agenda. Together with Vienna and Lyon, Munich is a lead city of the consortium Smarter Together, which includes over 30 partners from administration, industry and research, as well as three further so-called follower cities. Although the project revolves around the implementation of smart, data-driven infrastructures (the grand vision planned for the city involves the implementation of an app through which citizens will have secured access to smart services concerning transport, environment, etc.), what distinguishes the smart city agenda of Smarter Together in Munich is the targeting of a residential area and the implementation of a co-creation participatory approach. In its scope, the case of Smarter Together resonates with what we can observe in many European cities, where urban projects and interventions that go by the name 'smart city' do not (yet) involve systems or services based on real-time data analytics but rather encompass urban development projects. Indeed, investments in data infrastructures aimed at energy-consumption reduction and modal mobility split are only a small part of smart city investments which, in cities like Munich, opt for the building of multi-modal mobility stations, the energetic retrofitting of buildings or the renewal of street lighting systems. Accordingly, the notion of a data-driven city describes only a possible result, one possible framing of interventions in the built environment, but does not offer a key angle from which to look at these projects.

So how are we to trace the political trajectory of this smart city project in Munich, if the political-1, that is, the introduction of new socio-technical arrangements that subtly but effectively change the way humans and non-humans are articulated, is not the starting point of the story? That was the case with Foursquare which took us from the data-driven city as a subpolitical invention of a new way of constituting users by means of big data (politics-1) to an exploration of broader power formations (politics-5). The smart city project in Neuaubing-Westkreuz has followed a quite different political trajectory, one that actually begins with a sovereign decision of the city administrations to pursue and implement the project (politics-3), efforts for sparking publics into being (politics-2) and for achieving consensus through co-creation (politics 4).

Let us then begin this story by considering the city area chosen for Smarter Together in Munich taking into account the broader city-wide urban development master plan called 'Perspektive München', where Neuaubing-Westkreuz features as the first of the 10 urban areas to be intervened in before 2040. From this perspective, Smarter Together is an urban development instrument useful for this wider master plan, which ultimately relies on the capacity of the city administration to make collectively-binding decisions about the urban environment. Smarter Together thus involves an exercise and a reminder of the city administration's sovereignty upon the urban body under its jurisdiction. At stake is a modality of the political shaped by the juridical arrangements and institutional checks and balances of a city administration which corresponds to what Latour calls political-3. Starting from this observation, the political trajectory of Smarter Together that we would like to discuss here unfolds around the efforts of different actors, notably city officials, co-creation experts and local actors, to define what participation in this project should involve. We would like to dwell on this process, which we know especially well, given that one of the authors, Ignacio Farías, together with two colleagues from MCTS, Claudia Mendes and Hannah Varga, played the role of the co-creation experts in this process.

Interestingly, the expectations on co-creation held by city administration officials were based on their interest in design thinking methods that could foster creativity, lead to the proposition of 'cool' and 'crazy' ideas for smart technologies and services, as well as create a space where experts could learn about their prospective users. A good example of the latter was the encounter between mobility experts and local residents in the collaborative space called 'design collective: mobility', where the former were mostly concerned with achieving a reliable knowledge of user profiles and preferences. Co-creation thus was not imagined as a speculative exercise for developing new ideas, where the involved citizens could act as designers or planners, but rather as a technique to generate knowledge about prospective users so that mobility stations could be adapted to such user needs. Co-creation was imagined and practiced by city officials as a key technique for a consensual mode of the political (politics-4). Consensus was to be found through co-creation rather than through deliberation among rational actors, expressed in the design of the mobility station rather than in shared propositions and achieved through the common sense of creative citizens rather than through their argumentative capacities.

Such consensual politics was, however, significantly limited by the fact that there were in practice only few elements of the planned infrastructures that could be modified. In the case of the mobility stations, not only their location or number were out of the scope of co-creation but also the concerns brought up by participants, such as the improvement of cycling infrastructures, were outside of the scope of the project. A more promising opportunity for a co-creation process was carved out in the conversations between the co-creation team (Farías, Mendes, Varga) and the city's IT department in charge of the development of lampposts endowed with sensors. Apart from adaptive lighting and W-Lan connection, these lampposts are equipped with empty slots for sensors to be provided by private companies by means of a call for bids. Accordingly, the co-creation team conceived a whole process of hands-on activities aimed at bringing together public servants, technical experts and concerned residents to collectively shape the call for bids. The process would not involve the physical prototyping of sensors but it would require tinkering with the technical, legal and social parameters for sensors, as well as assessing the potential benefit of smart services enabled by them.

Even if this process was aimed at finding a consensus concerning the types of sensors and services to be provided, the co-creation team understood this as an opportunity to foster the formation of an issue-public concerned with sensor infrastructures and data issues in a collaborative space called 'design collective: data'. Indeed, the main aim of this co-creation process was not just to acknowledge the residents expertise in the matters at stake or to find a consensus about what the call for bids should include, but also to put experts in a situation in which their technical knowledge, value certainties and plans could be contested by a public (Farías 2017). In that sense, inspired by John Dewey's political philosophy, the aim was to create conditions for the emergence of an issue public that would explore existing uncertainties, produce and share knowledge and eventually confront the city with demands not yet considered in their smart city designs.

Both readings of the co-creation process as a consensual form of user engagement (political-4) and as the sparking of issue publics (political-2) are surely justified. There were moments in which the co-creation process functioned as a consensus-oriented device and moments in which residents, neighbours and interested and affected individuals and groups came together and acted as an issue public concerned with key issues that were not on the agenda, such as data privacy. Yet these two readings do not capture the mode of the political that most significantly shaped these participatory spaces and which was articulated around a different type of subject that is often called the *Berufsbürger* or professional citizen.

By *Berufsbürger* we generally refer to members of the organized civil society, often retired seniors, who have actively engaged with the project Smarter Together, voiced their concerns about its aims and foreseen interventions and, in some cases, also criticized the modes of public engagement characteristic of co-creation. Their qualification as *Berufsbürger* seemed appropriate considering their almost exclusive dedication to local affairs and their participation in all sort of activities irrespective of their thematic focus. In Germany the role played by *Berufsbürger* in participatory processes is mostly problematized as a representativity issue, given their specific demographics and the attached underrepresentation of younger people, less educated individuals, women and non-white citizens. Without underscoring the importance of these issues, we would like to highlight that the political challenge posed by the *Berufsbürger* was a completely different one.

To begin with, *Berufsbürger* were strongly against playful, hands-on and symmetrical modes of public engagement and participation. The first workshop of the 'design collective: data' involved playing a sensor game invented by the co-creation team. Each participant would get cards with information on specific sensors and come up with an application or service that run based on the data collected by these sensors. Each group would then build a mock-up of the sensor, as well as sketch out the kind of situations in which it would be useful. The skepticism with which this activity was received by some of the *Berufsbürger* was well captured in an email we received some weeks afterwards:

> Whereas on January 16, 2017 [date of the first workshop], many participants were there, during the event on January 26, 2017, I was the only one from the civic bodies [*bürgerschaftliche Gremien*] of the city district who attended. Something must have gone wrong, so that the interest of citizens and civic bodies in this project decreased so strongly. Was it the presentation with toilet brushes and clothes pegs at the level of a kindergarten or the insufficient information about the possible implementation of the project that made the interests of the citizens disappear? The Technical University should have been required to inform on what is technically possible, its meaningfulness and its costs (Email Communication, Date).

The email advanced two key propositions that radically challenged the way co-creation was being pursued. Firstly, the email implicitly suggested that what matters the most is the participation of representatives and members of local civic bodies and not whether or not the co-creation process was capable of reaching out and activating other residents concerned about the potential benefits and costs of installing sensor infrastructures. Secondly, the email quite strongly pleaded for a clear division of labour between experts and citizens. Experts should inform citizens about the technical feasibility, meaningfulness and costs of different technical options, citizens could then set priorities and make recommendations based on their knowledge of local needs.

Needless to say, this understanding of how public engagement should occur radically undermined the participatory agendas of the co-creation team (issue-public formation) and the city administration (user engagement). Indeed, *Berufsbürger* came to these meetings with a clear political agenda that involved pushing issues they have personally been concerned about for many years. Such issues would involve the installation of a mechanical escalator at an overground station, the building of a cycling lane in a traffic underpass or the allocation of municipal resources to a cultural center. By making demands that went well beyond the limits of the planned intervention, *Berufsbürger* were forcing all those involved to at least consider the ways in which the planned smart infrastructures are embedded in the local context. Most significantly, they often managed to steer a conversation about smart infrastructures into a larger conversation about local development ambitions, plans and agendas.

So how are we to consider the political modality enacted by these actors? It seems fair to say that *Berufsbürger* know very well where power to act in the local environment ultimately resides, namely, in the sovereign power of the city administration. Rather than a concern with the capacity of data to govern the city, *Berufsbürger* understand that the capacity to make binding decisions has been delegated to the city administration and aim at, if not influencing, at least making their cases in front of city administration officials. Politics here is not understood as ultimately involving a challenge to the existing institutional order but about finding the right moment to get the ear and eventually favour of the sovereign. The kind of sovereignty at stake here differs only partially from the one described by Foucault. Instead of open displays of the power to punish, it is based rather in highly formalised mechanisms of representation and delegation of power. The city is not run by absolutist kings but by an elected government who need to be re-elected and for whom a project such as Smarter Together will not prove to be a disaster. In a similar sense, Foucault (2007, 271) would point out, with reference to Machiavelli, that the Prince's main concern is not how to govern the people or the population but rather how to make sure that the most distinguished citizens, that is, the nobles, wouldn't plot against him.

Similarly, knowing that *Berufsbürger* are key political actors, multipliers in the language of city officials, the political challenge for the city consists in how to enroll them in the smart city project or, more precisely, how to let them use the smart city project as a resource for their own agendas and projects. The politics of the smart city appears here to be about the capacity of different actors to make compromises and build a network of allies, and the forging of such political alliances seem to involve a process of translation, as theorized by the thoroughly Machiavellian early actor-network theorists[2]. Translation, they argue, involves "all the negotiations, intrigues, calculations, acts of persuasion and violence, thanks to which an actor or force takes, or causes to be conferred on itself, authority to speak or act on behalf of another actor or force" (Callon and Latour 1981, 279).

[2] Machiavelli is indeed the model of early ANT regarding translation, with the only objection that Machiavelli doesn't sufficiently take into account the role of non-humans: "...how [much cleverer] it is to bind together men [...] by-wires, meters, copper, and filament lamps. Instead of a tiny list that includes love and fear, the modem Prince has a long-mixed list that includes many other elements in addition to love and fear" (Latour 1998, 9).

The enrolment of *Berufsbürger* is based on a political alliance that, at one moment, requires *Berufsbürger* to show interest in the smart city and allow the city to speak in their name, while assuming that at a different moment the city will need to show interest in their own problems and concerns.

Berufsbürger thus played a key role in the smart city project, also proving capable of redirecting project discussions towards local concerns hardly connected to smart and data-driven infrastructures. As a result, data, sensors and algorithms were becoming secondary (if not absent) elements in the political trajectory of Smarter Together. Indeed, the quest for a data-based urban politics – a quest pursued by both the city administration in charge of the project, as well as by the co-creation team in its ambition to form an issue-public around data infrastructures – was continually interrupted by these other matters of concern. This brings us back to the (cosmo)-political perspective with its emphasis on the contested composition of our common worlds. From this perspective the non-digital concerns of the *Berufsbürger* appear as a powerful grain of sand in the gears of a world-making machinery that often reduce cities to datafiable and computable problems. As such, the examples raised here remind us of the importance of looking at the ways in which smart and data-driven urban assemblages interact and collide with other ways of envisioning, valuing and practicing the city.

4. Thinking with and beyond the Data Driven City

In 1997, Amin and Graham advocated for a better consideration of "ordinary cities" against the tendency of urban studies at that time to take the cases of a few paradigmatic cities, or to consider only one aspect of city development, as totalizing descriptors for what the urban is or should be. These authors mentioned a "problem of synecdoche" (1997, 416) – a figure of speech where a part is used to describe the whole – to account for the ways in which expressions such as 'global cities' or 'creative cities' were used to characterize whole urban realities, regardless of the actually more complex, diverse and multi-layered nature of these realities. Turning to the ordinary city has not just involved paying attention to the multiplicity of urban assemblages that enact the city in diverse and often contradictory ways (e.g. Farías and Bock 2016), but also, following Robinson (2013), departing from the 'new' as a key heuristics to understand cities and moving towards a more complex analysis of the 'urban now'.

Exploring 'ordinary smart cities' is then crucial to avoid the potential totalizing-effect entailed by a description of cities as 'smart', while paying detailed attention to how smart city projects are fully embedded in a complex urban now, where pasts and futures are articulated in different ways. Notably, this involves, firstly, crafting an empirically-grounded and agnostic account of how smart cities are actually assembled and, secondly, emphasizing how – beyond a vision of the digital as the main driver of urban life – various actors and non-necessarily digital logics articulate and collide with smart and data-driven urban projects. In this article, we have done so by following the trajectories of two existing instances of smart urbanism: a smart service for urban exploration proposed by a private company (Foursquare); and a smart city project implemented by a municipality (Smarter Together). The two cases are rather unlike in their aims, in their rationales as well as in the type of actors they entangle, but together they entail a double decentering of the conventional understandings of the smart city.

Firstly, the juxtaposition of these two cases makes apparent that, in order to understand the fashioning of cities as data-driven assemblages, it is crucial not only to look at smart city projects run by city administrations but to consider the services offered by other non-governmental actors (notably, private tech companies). Our cases even suggest that the most advanced data-driven urban services are not necessarily occurring under the umbrella of smart city projects run by municipalities. Further, the case of Foursquare not only shows how such tech companies leverage the data produced by their users but also makes apparent the profit-oriented rationale for the constant re-invention, upgrading and expansion of the services offered. In this context, users are the essential basis of the company's business model. These need to be enrolled through the creation of attachments to the service in order for locational data to be farmed, aggregated and eventually capitalized upon – a mode of user engagement that radically contrasts with the participative and clientelist approach presented by Smarter Together.

Secondly, both cases required us to look beyond the digital, paying attention to how smart and data-driven cities are always entangled in, or articulating with, other non-data-centered urban development projects, logics or practices. Whilst the example of Foursquare illustrated the centrality of data – 'the new oil' – in market-based arrangements, the case of Smarter Together, to the contrary, evidenced how data and digital infrastructures were sometimes disappearing from the smart city agenda. Such non-digital logic was notably apparent in the role played by *Berufsbürger* and their local concerns in the implementation of this smart city project. This example allowed us to stress that the formulation 'data-driven cities' was not always a good descriptor of the new modes of urbanization currently coalescing around the construction of digital infrastructures. This also leads us to reiterate the importance of 'defetishizing' data and algorithms as central and powerful actors orchestrating urban life and allows us to look at the case of Foursquare from a different perspective, emphasizing how this apparently perfect case of data-driven urbanism is also articulating with non-datafiable attachments to and experiences of urban places.

The analytical consequence of this double decentering concerns how we study the politics of the smart city or, to put it differently, it raises the question of the conceptual repertoires that we can mobilize in order to grasp the multiplicity of ordinary smart cities and their politics. What has become clear is that we need to significantly widen the focus from a concern with what smart digital technologies do, or are supposed to do, towards the empirical study of the contested stories and trajectories of smart city projects, where functioning digital systems are nothing but one instantiation. Accordingly, studying these two cases, we were forced to go beyond a critical perspective that would exclusively focus on the ways in which digital technologies discipline or govern us, to a broader perspective on the (cosmo)politics of these human and nonhuman arrangements.

Empirically following the cosmo-political trajectories of smart city projects, such as Foursquare and Smarter Together, has also made apparent the incommensurability among the political modalities at stake. This incommensurability does not just imply that collectively binding decisions are made in radically different sites, but it also points to the absence of a common political language and instruments to articulate these various forms of smart urbanism. Here lies indeed one of the major political challenge for ordinary smart cities.

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The Urban Stack
A Topology for Urban Data Infrastructures

Aaron Shapiro
University of Pennsylvania (USA)

Abstract: In this article, I develop the concept of the "urban stack" to elucidate how urban data infrastructures gain legitimacy and produce value in capitalist cities. Using two case studies, I study how the stack can incorporate both digital and non-digital components into its hierarchical topology. Heterogeneous components are strung together not only through technological means, as might be inferred from the emphasis on digitality in smart city literature, but also through the 'soft infrastructures' of legal designations, franchise agreements, privacy policies, and info-graphics. A topological comparison between the case studies yields three novel insights: first, urban data infrastructures exploit extant infrastructural conditions; second, technical and protocological operations at the control layer can be used to legitimate ontological claims; and third, technology producers employ a selective and asymmetrical display of information at the level of the interface in order to manage mobile urban populations in real-time. From these insights, it is possible to reach a more abstract conclusion: value production for urban data infrastructures hinges on their producers' ability to enroll heterogeneous elements into their stacked configuration and to then use this configuration to control the flow of information.

Keywords: interface; infrastructure; on-demand economy; stack; urban data.

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Corresponding author: Aaron Shapiro, Annenberg School for Communication, University of Pennsylvania, 3620 Walnut St., 200 Philadelphia, PA 19104, United States. Email: ashapiro@asc.upenn.edu

1. Introduction: Beyond the Urban Interface

Our representational lexicon of the smart city is populated by all sorts of digital, touchscreen interfaces. As a nominal resource to citizens, these interfaces offer visitors "personalized streams of city data are rendered into 'actionable' information" (Mattern 2014). More often than not, however, the information on offer is pre-processed and presented to users as colourful info-visualizations that boast of the efficiency of city services but offer "little understanding of how and where the mediation of urban systems takes place within the city itself" (ibid). As Shannon Mattern argues in her critique of the smart city, if we truly want to learn about the politics of urban data and actually existing smart cities (Shelton et al. 2015), we need first to see these interfaces as the mere surface of vast, digital-material infrastructures that work by rendering the city as data.

Getting at these infrastructures means studying the composition of the operating systems and material supports that lay hidden, beneath and behind the interface: the vertical formation of interdependent layers of hardware and software that are stacked together, materially and protocologically, to produce the digital-material assemblage of the city (McFarlane 2011; Galloway 2004). This is what Mattern terms the "urban stack". Its hardware includes switches, wires, and cables; pipes, telephone poles, and gas lines; the transmitters and receivers of mass communication broadcasts, as well as wi-fi internet connections and 4G cell networks; the dirt, concrete, plastics, rubber, metal, and flesh that are the city's core materials. Its software involves elements of the digital interface – "all those zoomable maps and apps that translate urban data into something useful" (Mattern 2014) – but also other kinds of interfaces that need be neither public nor digital: the paperwork of the police officer, the ticket punch of the train conductor, the analogue clock atop city hall, the route of the postman/woman; the inscription devices that enable or constrain mobility (Peters 2013; Rose-Redwood 2006; Valverde 2011). Taken together, these assemblages of humans and their social practices, objects and their materials, infrastructured technologies and their interfaces, are what make the city an urban space, "not simply a context for the support or appropriation of specific lives," but "the provisionally stitched together, jigged up intersections of bodies and materials upon which things are both moved and caught" (Simone 2011, 356).

This article develops and extends Mattern's concept of the urban stack in order to advance our understanding of how and why the composition of digital urban formations matters. It focuses on two case studies of urban data infrastructures and the composition of their stacked assemblages: a public wi-fi infrastructure currently under construction in New York City, and the worker-facing apps employed in the "on-demand economy". I conclude by arguing that value production in the urban stack hinges on urban technology producers' ability to enrol heterogeneous elements into a hierarchical flow of information and, through this enrolment (Law and Mol 2001), to effect forms of control.

2. The Urban Stack

The concept of "the stack" is borrowed from software production, where it refers to a specific, hierarchical assemblage of hardware, network protocol, and software (Solomon 2013). Theorists of software and power have applied the stack as topology for mapping how digital media relate to and affect the material, cultural, legal, and political worlds in which they are embedded (Bratton 2016; 2014; Solomon 2013; Straube 2016). The stack itself, however, is a somewhat ambiguous analytic object. As Solomon (2013) writes, the stack topology conflates the "operative structure that exists materially within the program code of software systems" with the "class of diagrams used to explain both these operative structures and software systems more generally". Without being able to fully disentangle these two dimensions, the slippage between material structuring and diagrammatics is nonetheless productive; it reflects both the ways in which practitioners conceptualize the integration of software and hardware as well as the topological relationships within their integration. These analyses suggest that, while the stack is a specific type of assemblage, its specificity is revealing for data infrastructures that bridge material-digital divides – exactly what is at stake in the urban stack.

Here I follow Mattern's (2014) more liberal and heuristic use of the stack in order to conceptualize the relationship between data and materiality in the smart city. When applied to urban systems, the stack as a heuristic allows seemingly disparate data infrastructures to be juxtaposed in a meaningful way. More precisely, it can illuminate how data infrastructures enrol and assemble various objects, materials, human practices, technologies, and infrastructures into a looping structure of data flow (Kitchin and Lauriault 2014). Its implicit topological orientation reflects topological spatial thinking, "that some spatial problems depend not on the exact shapes of the objects involved but on the ways that they are put together, on their continuities, and cuts" (Secor 2013, 431). As I argue here, urban data infrastructures gather together digital and non-digital infrastructural components that, in their topological ordering, effect a privatization of material and infrastructural public goods. The protocological control that they perform works to enact a proprietary claim to that data (Thatcher et al. 2016).

Figure 1 shows how smart city practitioners adapt a stack topology from software development and apply it to the smart city imaginary. At the bottom of this diagram are various devices used to collect data about urban populations, spaces, and processes. In the smart city imaginary (Söderström et al. 2014), data collection is accomplished through the use of ubiquitous digital sensing and urban informatics – devices that are imperceptibly embedded within the urban landscape (Shepard 2011). In practice, however, much data collection involves both digital and analog data, as well as a combination of automated and manual collection processes[1].

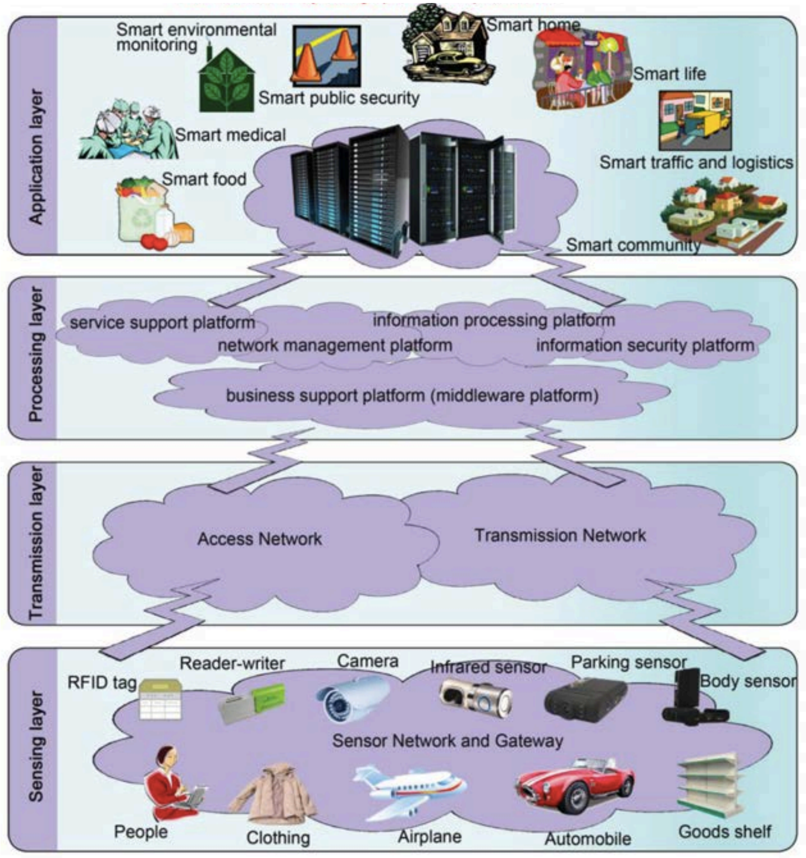

Figure 1 – The urban stack. Source: Liu and Peng 2014.

We can imagine this base layer as a *distributed infrastructure*, tethered together into a coherent program through its stacking. Urban data infrastructures rely on already-existing infrastructural conditions. Data collection and aggregation is highly opportunistic in this sense (Thatcher 2014).

[1] Data about bicycle ridership in New York City, for example, utilize traffic cameras with algorithmic sorting systems to automatically tag bike riders, but for sites where data collection is deemed valuable and such technologies don't yet exist, the Department of Transportation still places a staffer on the corner, manually counting cyclists by hand (cfr. NYC DOT 2016).

Infrastructures erected for one purpose are coopted for another. The same goes for networks and protocols, digital and otherwise. A company doesn't have to reinvent GPS, traffic systems, census tracts, or government bureaucracies in order to implement a new urban technology. But of course, such opportunistic cooptation of existing infrastructures is hardly acknowledged by smart city boosters.

In the middle is the *control layer*[2]. This is the level at which analogue and native-digital data are aggregated together, processed, standardized, and analyzed. It is also at this layer that most proprietary software systems take hold (Kanngieser 2013; Rossiter 2014). Regardless of whether the source is public or private, data at the control level becomes privatized through its analysis. Machine learning techniques employ data to train algorithms for improved accuracy, or to discover non-obvious relationships between disparate phenomena. As the cloud icons at both the Transmission and Processing layers in Figure 1 suggest, control is opaque to non-experts and outsiders. It involves code and interfaces that are not oriented toward end users, making them difficult to represent iconically (Chun 2011; Galloway 2012). Cloud icons stand in for the proprietary analytics that are so central to how value is imagined to be produced in capitalist systems (e.g., Mayer-Schonberger and Kukier 2012) – to how citizens are dispossessed of their data (Thatcher et al. 2016).

At the *interface*, processed data are presented to end-users through platforms that are both informational and informatic[3]. Interfaces are doubly communicative in this sense: they both gather and display information (Halpern et al. 2013). Notable is the highly selective and asymmetrical way that information is presented to different types of users, and the effects that such asymmetries can have. As Galloway (2012, vii) writes, "Interfaces are not simply objects or boundary points" but "autonomous zones of activity […] processes that effect a result of whatever kind". The selectivity by which information is communicated to different users is derived from a set of decisions made by technology producers to achieve desired effects from users' interactions. Such decisions are thus an important source of control in urban space and a key objective amongst urban technology producers who utilize urban data. The uneven distribution of information, which hails different user-types as subjectivities (see Dalton et al. 2016) and augments patterns in urban mobility, is similarly an oft-neglected component of digital urbanism.

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[2] The term "control layer" is borrowed from early descriptions of how GPS technologies work (Kaplan, cited in Kanngieser 2013, 604).

[3] The present discussion is limited to the types of urban interfaces that Mattern (2014) considers as the "points of engagement" through which smart city practitioners imagine citizens will interact with smart city operating systems – screens, dashboards, displays, graphical user interfaces, etc.

3. The City of the Future: Two Case Studies

The hierarchical topology of the urban stack helps to elucidate how value is produced and control exercised through urban data infrastructures. How technology producers construct new stacks, or take advantage of stacked assemblages already in use, affords control over the flow of data and the production of new data ontologies (Kitchin and Lauriault 2014). Through a consideration of two case studies of urban data infrastructures, I illustrate how value is produced and legitimacy ensured by controlling the flow of information. These case studies share a number of similarities in how heterogeneous elements are assembled together to effect a stacked topology: each relies on the affordances of externalized infrastructures; each utilizes technical and protocological operations at the control layer, not only to extract value but also as a form of technological legitimation; and each employs a selective display of information on the urban interface as a way to manage mobile urban populations in real-time (Kanngieser 2013; Levy 2015; Rossiter 2014).

3.1 The Future of Public Spaces

In 2014, New York City Mayor Bill De Blasio announced that a consortium of private companies had won a Request for Proposal (RFP) to implement a vision of what the future of public spaces would look like (NYC.gov 2014b). This vision came in the form of an infrastructure for free public wi-fi called LinkNYC, slated to become the world's fastest municipal wi-fi infrastructure and largest outdoor advertising network (ScreenMedia 2014). Intersection, the for-profit conglomeration of two existing companies – Titan and Control Group, an out-of-home advertising firm and technology design company, respectively, along with consulting by technology giants Qualcomm and Comark (NYC.gov 2014a) – was now licensed to implement, operate, and maintain the LinkNYC infrastructure. The potential advertising revenue generated by LinkNYC, to be split with the City of New York, makes the infrastructure an attractive model for other cities. Much larger players, including Google's Sidewalk Labs, quickly garnered interest in the project (Ingraham 2015), and there is already talk of replicating LinkNYC in other cities (Kinney 2016; Tadena 2016).

LinkNYC utilizes the city's extant payphone infrastructure to create a network of kiosks, called "Links," that provide free wi-fi access with a radius of at least 150 feet (and up to 500), free telephone calls to anywhere in the United States, and, through the touch-screen interface, free access to information about city services. One of LinkNYC's key features is that users receive a unique token that allows them to move within and across network nodes without having to log back into the network each time their device is "handed off," meaning that this meshed coverage has the potential to be extensive in certain areas (I Quant NY 2014). One estimate suggests that LinkNYC's overall coverage will include more than a third of New York City's land area[4]. Construction of the Links began in late December, 2015 in a rush to meet the stipulations of the service agreement (Brandom 2015). Several hundred Links now dot Manhattan, the Bronx, and Queens, with between 7.500 and 10.000 planned for implementation across the five boroughs. Each Link comes equipped with two 55-inch digital, LCD signage displays dedicated to advertising (ScreenMedia 2014). The expected windfall of advertising revenue is slated to pay for the infrastructural overhaul and to yield an approximate $500 million for both the public and private entities involved over the next decade (Department of Information Technology and Telecommunications [DoITT] 2014).

LinkNYC's potential for generating urban data has been celebrated as invaluable for urban planning purposes (Fung 2016; Hotz 2015; NYC.gov 2014b). Despite repeated concerns about privacy infractions on the network (e.g. NYCLU 2016), the promise that LinkNYC will provide real-time data about mobile urban populations to institutional actors – including real estate developers, city planners, app developers, advertisers, metropolitan police, transit authorities, etc. – is an important mechanism for establishing the infrastructure's legitimacy (cfr. Gustin 2016). In the words of Intersection's Chief Strategist Dave Etherington:

> When you think about LinkNYC and the 7.500 or so fairly evenly distributed nodes across the five boroughs, then that does represent a really interesting opportunity to learn about the city, the behaviours of the city, that could lead directly to health benefits, more efficient use of traffic – being able to sense, are trucks idling near these things illegally? Is there congestion? Is there a traffic jam? Is there noise pollution, air pollution? All of these things, by microlocation, could really empower some really interesting insights about the city that will make it a kind of more enjoyable place to live (Behind the Numbers 2016).

To quell lingering privacy concerns, Intersection developed a concise (if still vague) privacy code (NYC.gov 2016) outlining the technical protections in place. Data shared over the networked will be encrypted and automatically anonymized by unique, randomized keys for each MAC address that logs onto the wi-fi network. LinkNYC also promises not to track web browsing histories on devices connected through the wi-fi. However, even if these technological solutions and protections for privacy prove effective, data generation will continue apace. This is because LinkNYC's most valuable data-infrastructural affordance is its ability to simply count people: "We do not collect information about your precise location. However, we know where we provide Wi-fi services, so when you use the Services we can determine your general location" (NYC.gov 2016). By virtue

[4] Manhattan's coverage may be as high as 50% while other areas could be as low as 16% (I Quant NY 2014).

of logging into the LinkNYC wi-fi, users will be counted, in place, in real-time. The system may "combine Technical Information or non-Personally Identifiable Information about your use of the Services with similar information about other users in an aggregate or anonymous manner" in order to "measure or understand the effectiveness of advertising we serve to you and other customers like you, and to deliver relevant advertising to you" (ibid).

There is also the potential for LinkNYC to count people who are not logged onto its wi-fi (cf. Musa and Eriksson 2012). Evidence of this can be gleaned in documentation of the LinkNYC technical capabilities as well as by considering how companies in the Intersection consortium have behaved historically. In 2014, Titan, Intersection's advertising arm, installed Bluetooth low energy (BLE) beacons on New York's payphones, which are capable of counting all devices with wi-fi and Bluetooth connection capabilities within its range. When it was made public that Titan had installed these devices without notifying citizens, the New York City Department of Information Technology and Telecommunications (DoITT) required Titan to remove the beacons (Bernstein and Ryley 2014). This same technology is built into the Link system (Intersection 2016), although representatives from Intersection claim that they have not yet been turned on (Gustin 2016).

The technological capacity to silently count readable devices is not new, nor is it limited to LinkNYC[5]. What is new about the LinkNYC's potential data collection is the granularity and penetration that it achieves. With smart phone penetration reaching 80% of New Yorkers in 2015 and still growing (NYC Dept. of Consumer Affairs 2015), LinkNYC is poised to generate real-time locational and mobility data on a majority of New York's population. The uses towards which this data might be put are, at present, limited to the twinned domains of advertising and urban planning. Where the urban planning uses of data legitimates LinkNYC's silent locational data collection, the advertising revenue generated for the City likewise legitimates the public-private partnership between Google-backed Intersection and the City of New York. The normalized dwindling of public service provision in neoliberal or entrepreneurial cities (Harvey 1989) opens a market-space for private companies to capitalize on infrastructure and to label it "innovation". In Intersection's Chief Strategist Etherington's words:

> The advertising concessions related to this infrastructure are seen as vehicles for innovation and that's really where we're at in our focus from the media side – that,

[5] In 2013, an IT worker discovered that the New York Department of Transportation had been silently scanning drivers' EZ-Pass tags (RFID cards for automatic toll collection), in order "to monitor the flow of New York City traffic […] scrambl[ing] the serial numbers to anonymize vehicles and their owners." See http://www.popsci.com/article/diy/ezpass-hack-covert-scanning (retrieved April 30, 2016).

with these advertising contracts, we're able to introduce not just increased advertising revenue for cities, but we can bring in new technologies and new innovation (Behind the Numbers 2016).

The desired outcome of LinkNYC is to transform public spaces into sites of real-time data generation that can be capitalized on through advertising sales. The release of this data to urban planning agencies legitimates not only the City's involvement, but also the private company's right to silently collect and analyse urban data without even tacit consent.

3.2 The Future of Work

Recent discussions about the future of work have emphasized the role that app-based platforms will play in making labour economies more flexible (e.g., Hanrahan 2015). This debate is especially important for cities, given the growth and concentration of the service sector as a major local economic industry in urban areas in the U.S. and elsewhere (Lopez-Cermeño 2015), as well as the impact that work platforms have already had on cities (Zumbrun 2016). Prominent examples include informal taxi services Uber and Lyft, and courier services like Caviar and Postmates. These companies profit from the algorithmic management of fleets of independent contractors who, through worker-facing apps loaded onto their mobile smartphones, connect with customers seeking delivery or taxi services. Fleet management apps work as semi-automated systems for labour assignment and oversight (Rosenblat and Stark 2016, 2). They use closely-guarded algorithmic calculations to set prices for both customers and payouts for workers. If described at all, explanations of these algorithmic calculations are cloaked with vague terminology about the distance of a delivery or a taxi fare, or even shifting levels of demand. Neither the customer nor the worker has access to the full information (Kirchner and Mattu 2015).

The term "on-demand economy" describes the experiences of both customers and workers for these platforms. What these companies deliver is quasi-luxury, hyperlocal mobility – the movement of goods (as in the food courier platforms Caviar and PostMates) or people (as in the taxi and black car services Uber and Lyft): door-to-door service, ordered with the push of a button, just-in-time and on-demand (Ruckelshaus 2016). Workers for these companies, designated as independent contractors rather than employees (Scheiber 2015), are enticed with the promise of flexibility – working whenever they choose, deciding whether to accept or deny any job in the form of delivery or ride request. Work, like the service, is available on-demand: workers log on whenever they want and choose which jobs to accept or reject. But labour is also on-demand: workers are not paid without completing an order or a fare, and order allocation is dictated by the same opaque algorithmic calculations that determine the payment for a given job (Rosenblat and Stark 2016)[6].

Despite the promise of flexibility, in practice, on-demand platforms employ numerous disciplining techniques (such as ratings systems and accountability indices) to cajole workers into adhering to some sort of scheduling system or acceptance rate – the same rigid components from which flexible working was meant to depart (cfr. Graboyes 2016). For instance, Caviar, an upscale food delivery service available in fifteen of the country's largest metro areas, sends an automated weekly email to its workers with a breakdown of completed orders and payments[7]. The company recently introduced a new component to this email, an index of workers' scheduling reliability, which calculates the ratio of time spent logged into the app during a scheduled shift. Workers are contractually not obliged to commit to scheduled shifts, but for management, having a schedule helps plan for predicted ebbs and flows in demand. The index impresses upon the worker his or her standing as reliable, despite its contractual irrelevance. Several indicators are excluded from this index that could just as easily reflect a worker's reliability. For example, when understaffed, the company sends out a notice to encourage couriers to sign on; the scheduling reliability index does not account for how often a courier responds to these emergency requests[8]. Nor is there a calculation of what percentage of time a worker sat idle during his or her scheduled shift – logged on, but not receiving orders and thus not getting paid.

What is most striking is the opacity around whether or not this ratio affects one's rankings in the algorithmically-defined queue of couriers used for dispatching orders. As one Caviar courier explained during an interview:

> When I first started working for Caviar, I was told that we weren't obligated to accept orders. It's completely at our discretion when we want to work and what orders we want to accept. That was a big selling point for them looking for couriers […]. Now, they're doing this [scheduling] reliability system […]. It feels like Caviar is trying to guilt trip us for not showing up for our shifts, which are not obligatory, and whether or not we're being penalized for showing up for our shifts is kind of unclear. But whether or not they're penalizing us, it seems like they're asking us to penalize ourselves[9].

Another example is Uber's policies for deactivating drivers. Prior to the

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[6] Contrary to this model, some have argued that since Uber and other companies do profit off of drivers even when they are not delivering a passenger, workers should be paid for their time.

[7] My methods for this research include working as a Caviar courier for 12 months; I received these emails while working for Caviar.

[8] A typical notice, which is called "the bat signal" by management, reads "Lunch is busy NOW and we are understaffed! Go online NOW to take full advantage of this lunch bizness, Philly!" (received 5/3/2016).

[9] Interview conducted March 7, 2016.

settlement of a class action lawsuit (Isaac and Scheiber 2016), Uber was opaque about its deactivation policy. Rationales ranged from inactivity (not working for 90 days) to low acceptance rates (the ratio of how many rides a driver accepts to how many requests he or she receives) (Dough 2016). These disciplinary techniques are automated and incorporated into the technological fabric of workers' day-to-day labor practices.

In addition to mechanisms that belie the flexibility of on-demand work, on-demand platforms are also characterized by their highly selective and asymmetrical display of information within the worker interfaces (see also Rosenblat and Stark 2016). Lyft drivers see maps that show them areas where surge pricing (or Prime Time) is in effect. In these areas, passengers are subjected to higher rates due to local distributions of demand (or algorithmically-predicted distributions of demand) at a given time interval (Chen and Sheldon 2015; Kirchner and Mattu 2015; Rosenblat and Stark 2016). Workers argue that dynamic pricing is a fleet management technique used to incentivize drivers to go to busier areas. But since the algorithmic calculations that determine surge pricing are opaque to drivers, as are the number and whereabouts of other drivers on the road at the same time, there is no guarantee that going to a surge zone will mean getting a well-paying job. In another example, the courier apps often obscure the address of a delivery drop-off when the worker is prompted to accept or reject an order. High rise apartments or office buildings can be unattractive to couriers, since payment is calculated based on the ground-distance between the restaurant and the delivery address and not on how much time is spent getting to an apartment or office. Knowing that a drop-off location is on the 25th floor might thus be a disincentive for a courier to accept the job; the company's interest is thus to omit this information until a courier has already accepted the order. Such informational asymmetries give workers just enough information to complete a task, but obscure enough information that the company's interests appear to be in the workers' as well.

4. Topologizing Urban Data Infrastructures

The case studies presented here differ in interesting ways. LinkNYC is a large infrastructural overhaul managed by private firms and marketed as a public good in the form of free wi-fi; apps in the on-demand economy are much more distributed and explicitly focused on extracting value from workers. Despite their differences, the two cases share much in common, and their similarities can be fruitfully highlighted by employing the topology of the urban stack. Using the stack as a heuristic, these cases can be *bent* and *stretched* to facilitate comparison (Secor 2013), which, in turn, can help to expand our understanding of how "actually existing smart city" interventions (Shelton et al. 2015) are legitimized, and how controlling the flow of information can produce capitalist value.

4.1 Distributed Infrastructures

Both case studies rely on a distributed infrastructural base upon which other elements are stacked to create small monopolies of data collection, storage, and analysis. This distributed base externalizes costs and mitigates risk by taking advantage of extant infrastructural conditions. With LinkNYC, there are two ways that extant infrastructure is enrolled into the network. First, LinkNYC exploits the sunk cost telecommunications infrastructure already in place in New York City, constructing its hardwired connections between the Links within the conduits built beneath the surfaces of New York's most densely packed pockets (PlaNYC 2013). Fiber optic connections can be strung through conduits, which can be accessed simply by opening a manhole cover. LinkNYC is being built without having to break ground. Second, LinkNYC relies on the growing penetration of smartphones amongst New Yorkers. Smartphones and other readable devices, such as tablets or laptops, even if not actively connected to the LinkNYC wi-fi networks, serve as de facto sensors for LinkNYC's production of real-time data about urban populations. This data collection is integral to its legitimacy.

In the on-demand economy, the most profound way that companies take advantage of distributed infrastructures hinges on the legal designation of workers as independent contractors rather than workers. The questionability of this designation was recently deferred by the settlement of a class action suit involving Uber workers in Massachusetts and California (Isaac and Scheiber 2016). For on-demand services like Uber, Lyft, or Caviar, this deferment is a boon: not only do the companies remain free from being required to cover employee expenses such as Social Security and workers' compensation, they can continue requiring workers to provide their own means of communication and transportation – typically a smartphone and a bicycle or car. Employees are left to cover the costs of data bills and fuel, as well as for any upkeep and repair to vehicles due to wear and tear incurred while working on the road. Further, companies are legally prohibited from providing tax education to workers, as this would breach the legal distinction between independent contractor and employer (Mishel 2016). On-demand economy companies have proved successful at enrolling workers who are willing to supply their own means of transportation and communication – costs that employees typically do not cover. The infrastructural conditions that facilitate that rapid, on-demand movement of people and things in this sector is thus outsourced to the workers themselves, both in terms of their own bodies and labor (including risk of injury, healthcare coverage, fatigue, etc.) and in terms of their privately owned consumer technologies, which serve as networked infrastructural components[10].

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[10] The outsourcing of labor in the on-demand economy is reminiscent of 19th century telegraph messenger boys, who, as Downey (2003, 134) argues, were both

4.2 Control

Control is exercised in both the LinkNYC and on-demand economy examples through the effects of black-boxed regimes of calculation. In the case of LinkNYC, two functions at the control layer will be key to its success. The first is the hidden protocological activity that randomizes or anonymizes user identification in order to ensure privacy. These protocols transform aggregated user data into a format that can become informationally meaningful while simultaneously providing a technological solution to concerns over privacy. The second function at the control layer involves the dynamic, algorithmic calculation of pricing for advertising that will be based on this information (Behind the Numbers 2016). Once a real-time count of devices is in place, algorithms will not only "allow advertisers to deliver highly targeted content to passers-by, [which] works similarly to ad-targeting algorithms users encounter while surfing the Web" (Campbell 2016), but also to create a dynamic pricing model such that ad space costs more when more people are around to view them (Shpanya 2014). As one online advertising trade magazine explains, the Links' "strategically placed, networked digital signage displays" are situated within "a larger multiscreen ecosystem that effectively amplifies brand messages to create a deeper level of engagement with active consumers [...] with highly targeted messages" (ScreenMedia 2014). LinkNYC's real-time data on the ebbs and flows of urban populations will be able to make already-valuable out-of-home advertising space even more profitable by charging advertisers more during periods of high traffic.

With on-demand economy smartphone apps, the control layer is largely hidden from workers, effecting an informational asymmetry that can be leveraged to manage large fleets of workers in real-time (Rosenblat and Stark 2016). Control is manifest in the proprietary algorithms that determine which couriers or drivers should be matched with which deliveries or riders, where, when, and at what price (Chen and Sheldon 2015). The proprietary nature of these algorithms is central to the profitability of companies in the on-demand economy. But it is also important in legitimizing claims that on-demand companies are not service providers, but rather technological platforms that serve merely to connect supply and demand. Such claims are important, since they legitimate the designation of workers as independent contractors, who supply their own modes of transport, communication, health insurance, etc. As one Uber engineer wrote in a widely read forum about Uber on Quora:

> A taxi company contracts drivers, deals with vehicles, pre book rides [sic], etc. Uber deals with building data centres, running real time software services, facilitat-

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"active components" of telegraphy as a technological system and "laboring agents within produced urban spaces".

ing payment and conducting research into the economics of real time transportation automation, among solving all sorts of other interesting technological problems – all things that are not done by a taxi service. It's a totally different operation from what a taxi company or a transportation service does […] Uber is not a taxi company, but a technology company that provides solutions for people's transportation needs [just like] eBay is not a shopping mall, but a technological platform that enable [sic] private sellers to find buyers for what they have to offer (Tal 2015).

Activity at the control layer allows for dynamic pricing models that exploit surges in demand, allocates orders to the lowest-costing courier or driver based on the distance to the customer, and, ultimately, serves as a justification for the companies' designation as technology producers rather than urban transportation or logistics services, which would be regulated more stringently.

4.3 Interface

Finally, the selective display of information at the interface level is key to the functioning of both LinkNYC and on-demand economy companies. On the one hand, the omission of information can be used tactically to realize certain effects. This is clear in the on-demand economy's worker-facing apps. For example, the Caviar Courier app has a sequence through which couriers must step through when accepting, picking up, and delivering an order. Throughout this sequence, certain bits of information are given while others remain omitted. The need-to-know basis of information here is productive: it gives workers just enough information to complete the task at hand, but not enough for them to gain a full understanding of how the system works and thus optimize their output in the form of payments. The same could be said of LinkNYC's interfaces and the "larger multiscreen ecosystem" (ScreenMedia 2014) into which they fit. This ecosystem is both informational and informatic: usage generates data. But these data are systematically excluded and consciously hidden from interface displays (Chun 2011). The doubly-communicative interfaces are designed such that individual users can never access the full scope of information relevant to the landscape in which they're operating, but are expected nonetheless to use the information that they do have to maximize private gain. This reflects Mattern's (2014) point about the trade-offs implicit in the smart city interface; they "suggest that we've traded in our environmental wisdom, political agency and social responsibility for corporately-managed situational *information*, instrumental rationality and personal consumption and convenience. We seem ready to translate *our* messy city into *my* efficient city" (original emphasis).

But if certain information is selectively omitted or excluded, other information is strategically included in order to achieve certain effects. In the on-demand economy's worker-facing apps, information about worker reliability and productivity is tactically deployed in an effort to discipline workers into conforming to the rigid elements of supposedly flexible work.

Indices and info-graphics about the worker's performance are described by workers as "mind games" or "guilt trips". These techniques are common to the integration of digital surveillance mechanisms within the workplace (Kanngieser 2013; Levy 2015; Rossiter 2015). With LinkNYC, the potential for advertising displays to direct the attention of passers-by to local consumer points of interest is a subtler form of managing mobility. Hyperlocal, modular ad displays can be designed to steer potential customers to local restaurants, cafes, shopping centres, department stores, with the promise of discounts or coupons: "You can expect the [LinkNYC] kiosks to start telling you there's a table for two open at the French bistro down the street, for instance. Or that the subway station nearest you is offering limited service due to repairs" (Fung 2016). This kind of hyperlocal notification allows those with access to the network's counting capabilities to produce market value through the targeted modulation and steering of mobile urban populations.

5. Conclusion

The urban stack is a productive heuristic with which we might better understand how urban data can be made a valuable commodity. Using the two case studies of LinkNYC as a data-generative municipal wi-fi infrastructure and the worker-facing apps of the on-demand economy, I showed how the stack can incorporate both digital and non-digital components into its hierarchical topology, including telecommunications conduits located beneath the streets in Manhattan and other parts of New York City, as well as mobile fleets of drivers and bikers, as infrastructures for facilitating or steering the movement of goods and people. I have also illustrated that heterogeneous components are strung together not only through technological means, as might be inferred from the emphasis on digitality in smart city literature, but also through the "soft infrastructures" of legal designations, franchise agreements, privacy policies, and info-graphics, as well as the dispersed infrastructure of transportation and communications maintenance.

Using the urban stack to construct comparisons across urban data infrastructures yields novel insights. Here I have shown how urban data infrastructures rely on the affordances of externalized infrastructures by exploiting extant infrastructural conditions. Further, both LinkNYC and companies in the on-demand economy utilize technical and protocological operations at the control layer to extract value from digitally-mediated interactions. LinkNYC legitimates its data collection practices through technological means to secure privacy and the promise of sharing this data with urban planning actors, while for companies in the on-demand economy, control layer activity legitimates claims about the status of workers as independent contractors rather than employees. Finally, in both cases, technology producers employ a selective display of information at the level of the urban interface to manage and capitalize on the movements of urban populations in real-time. From these insights, it is possible to reach a more abstract conclusion: value production for urban data infrastructures hinges on their producers' ability to enrol heterogeneous elements into their stacked configuration, and then use this configuration to control the flow of data and information.

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Discovering the Data-driven City
Breakdown and Literacy in the Installation of the Elm Sensor Network

Darren J. Reed
University of York (UK)

Abstract: In this article, we examine the role of environmental big data in the installation of an environmental sensor in a UK city. Taking the installation of the Elm sensor as an empirical case study, we understand the installation as incurring an instance of natural breakdown which reveals the contingent workings of the device, and places it in the context of the practices of normalisation and stabilisation of the device. We use this to ask questions about the taken for granted smoothing of outputs and the continual elaboration of use and design, alongside the constructive potential for disruptive digital literacies as a site of intervention. By following, empirically, the installation of the technology, we are led to combine, and re-examine, theoretical lines of reasoning about data competences and relationships, and in turn advocate a form of 'material politics'.

Keywords: environment; big data; digital literacy; material politics; environmental sensors.

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Corresponding author: Darren J. Reed, Department of Sociology, University of York, Wentworth College, W/241, Heslington, YO10 5DD, United Kingdom. Email: darren.reed@york.ac.uk

1. Introduction

This article follows the problems encountered in the installation of a new environmental sensor, and reveals the potential for new relationships between members of the public and environmental monitoring sensors data, as a site "of intervention where new data actions and relations might converge" (Gabrys 2016, 4). It is premised upon an empirically inspired, theoretical examination of the installation and configuration of a commercial product, the Elm sensor, and uses this work to open up and reveal the strategies of data manipulation of the device installers and the existing infrastructures of the city. In response, it extends the arguments of Noortje Marres (2012), and her reasoning about the potential for political action in the real-world situation of engagement with environmental data, by advocating the nurturing of "new data literacies", particularly those deemed "disruptive", as a form of intervention based upon the creative engagement with the rich complexities of environmental data. The article rests on the history of work in Science and Technology Studies (STS), and *the performativity of technology to effect* new social relationships (Law and Singleton 2000; see also Barry 2001). Rather than starting with an ideal participant, it follows the technology and the way the script (Akrich 1993, 206) of the competences and "geographies of responsibilities" are elaborated, to inform the potential for new forms of civic participation. There is a growing interest in smart cities in the social sciences (Kitchin 2014) and spatial data (Leszczynski and Crampton 2016). These are related to an emerging focus on environmental big data (Gabrys 2016; see the special issue of Big Data & Society, 2016) and the way they allow for an engagement with "practices, materialisations and contestations" within deployment processes (Akrich 1993, 3). Such moves complement those that seek to engage big data as they are made meaningful in everyday life (Wilmot 2016; Pink et al. 2016).

The Elm sensor is a modular device developed by the American company Perkin Elmer. At the time of writing, Perkins Elmer has handed over rights to the development of the device to the University of York, but its origins lie in an idealised notion of the potential for new environmental sensors and public participation. Jon DiVincenzo, President, Environmental Health at Perkin Elmer had this to say about the sensor at its launch, "the Elm network is designed to create better awareness, empowering all of us to connect our understanding about the quality of our environment with its long-term impact on our health - helping cities and their populations make smarter, more informed decisions" (http://ir.perkinelmer.com/).

The position espoused in the above quotation is one based on a technological deterministic line; the technology is characterised as effecting these positive outcomes without recourse to the social context of their installation and use. The sociological approach to critical data studies (Iladis and Russo 2016), and in particular environmental devices and data, take a critically reflective stance to this position. As Kitchin (2014, 8) points out such technologies and the data they produce are inherently political and are not neutral, "[d]ata do not exist independently of the ideas, techniques, technologies, people and contexts that conceive, produce, process, manage, analyze and store them". And further, "data are inflected by social privilege and social values" (ibid).

A so-called "technocratic view" presents the idea that data is benign and the more we have, the more likely we will be able to make good decisions. Yet as Kitchin points out, such a viewpoint ignores the contextual, contingent, and relational nature of such data, in its production, use, and effects. In Kitchin's terms "[i]t is less well suited to contextualising such data or revealing the complex contingent and relational inner lifeworld of people and places" (2014, 9). In this article, we argue for an approach based on "new data literacies" as critical intervention, a deliberate re-focussing on the potential for encouraging and supporting the meaningful agency of people in their relationship with environmental sensors and the data they produce by resisting efforts to 'smooth' the data before presentation. We mean this as a critical intervention. That is, we are not advocating a return to an individual competence model or requirement for device functioning, but a 'de-stabilising', premised upon the possibilities for the redistribution of agency and formation of new actor-networks.

The University of York, became involved with the Elm sensors when it placed it at the centre of a research project called YorkSense. Subsequently, the sensors have become central to two other research initiatives at York, the CAPACITIE project – an EU Initial Training Network for new Environmental Scientists, and the York City Environment Observatory (YCEO) – a pilot exercise to develop the city of York into a base for environmental sensing and stakeholder engagement (for more details see https://www.york.ac.uk/yesi/projects/yceo/). Both YorkSense and YCEO espouse a particular model of the data-driven city premised upon open data seen in the central involvement and use of the York Open Data platform (www.yorkopendata.org). These initiatives combine to form a concerted effort to establish York as a "data-driven city", premised upon citizen access and active engagement.

The YorkSense project had the simple aim of installing 100 Elm sensors in York as a test bed for their use and development in other urban settings. The author was attached to this project as a sociologist concerned with stakeholder relations alongside positional deployment choices (new to schools etc. – see below).

The deployment in York suffered several delays in relation to the technical configuration of the devices. These included unforeseen problems with finding an appropriate power supply and negotiating with the local council for the use of existing lamp posts for this purpose. In addition, it was found that the sensors did not give constant readings, neither between devices, nor when compared with other, more expensive, monitoring systems. Rather than view these delays as faults in the system of installation, this article takes these delays as instances of the real-world configuration and (re)stabilisation of the devices as a working system – that is in a sociotechnical sense, which interweaves technical functionality with appropriate social functioning (Bijker et al 1987; Mackenzie and Wajcman 1985). As such the social and interactional qualities and practices of installation and deployment are viewed as ethnographic research data, and a "probe" (Gaver et al. 2004), or prompt, for sociological analysis. It should be emphasized therefore that this was a partial ethnography, and we would foreground the limitations of such an approach. The details conveyed below are perspectival, premised – as they are – on the experiences of the installation efforts by the researcher as part of the team. The provision of limited ethnographic 'snapshots' are a consequence of this participatory position. It is true that such a position runs the risk of undermining the agency of the research (as independent actor). At the same time, the features included were central concerns for the installation stakeholders; they key off the "sense-making practices" (Garfinkel 1967) within the installation process and are therefore true to the members' sense-making practices, perspective and proximity to the process.

We first outline the key issues encountered by the installers, and then introduce sociological theory to help open up the process as a case study, drawing on foundational literature in Science and Technology Studies, specifically the work of Akrich (1992, 205) and the "(de)scription of technical objects".

We extend this idea by noting the 'de-scription' of the algorithm possible through the ethnographic work, that is the unpacking of the manner of algorithm formation, and adaptation to an imagined (confused) user. Once understood in sociological terms, the issue of the materiality of these objects as enacting and configuring new forms of political participation is detailed through the work of Marres (2012). This line of reasoning, led us to consider what we call "new digital literacies" based on work of Lankshear and Knobel (2008). We extend this line of reasoning with what Couldry et al. (2016, 118) call "real social analytics". While these authors come from different scholarly traditions and represent different conceptual viewpoints, we rationalise their combination through the concerns of the designers and academics with "literacy and agency". That is their coherence comes from a sensitivity to the research domain, rather than adherence to a particular position. The agency and experiences of the user as a social actor re-emergences as a central concern. From here, we speak to the potential for new 'disruptive' literacies and their place within a form of engaged citizenship based on critical and creative engagement with data.

2. The Case Study: The Deployment of the Elm Sensors

The Elm sensor was developed by Perkin Elmer, a large US company. The company partnered the University of York on a locally funded project in the Environment department called YorkSense, which had the explicit aim of installing 100 sensors in the city of York UK, between July and December of 2015.

The Elm device is a multi-sensor air quality monitoring device that measures particulate matter (PM), total volatile organic compotes (VOCs), nitrogen dioxide (No2), as well other atmospheric components. It is a modular system; such that new individual sensor components can be added over time. Data is collected and then transmitted over GSM to a central cloud storage. The results of which are then presented on the Elm websites[1] (Williams et al. 2015).

The research team was comprised of academics from the departments of Environment, Chemistry, Computer Science, and Sociology at York University. In addition, technical support was supplied by members of the Electronics department. On the York Council side, various departments partnered the research, including those concerned with transport management, asset management (street lamps etc.) and the Business Innovation unit.

The author was attached to YorkSense as an ethnographer, which entailed following the installation process, and advising on the deployment locations, and researching the relationships between stakeholders. In good part, this entailed an appreciation of the likely users of the eventual network of devices, as well as giving advice on how the interface to the output data might be developed and refined (the author's history in Human-Computer Interaction, and interaction design providing a foundation for such recommendations). The author attended planning meetings, viewed the sensors in place, and interviewed various stakeholders (members of the council, colleagues in the environment department) involved in the project. Central to these efforts, and the account given here, was a slow revealing of the underlying issues based upon unanticipated issues and problems. The article takes (theoretical) issue with the (empirical) decisions and discussion of the installation process. The script – as such – emerged from these decisions and practices, and could be said to be unfinished from a design point of view (as the sensors are not yet deployed). The materials contained in this article come from notes taken in meetings, and informal discussions (with the researcher being part of the installation team). The quoted materials (graphs etc.) come from project presentations and emails discussions.

Key to the story is the unanticipated delays encountered in the simple technical functioning of the devices. Rather than being deployable 'as is', it was realised early in the process that the device was not 'field ready'. Alongside other practical matters – such as finding a power supply for each unit, and accounting for and adapting to data transmission drop out (more below) – it was quickly realised that the readings from each unit were not only divergent (in that they gave different readings to one another) but, more importantly for our purposes here, some of the readings were judged to be inappropriate for a number of reasons. These are instances of "practical meaning-making" in that the project partners anticipated that the users of the system would read the outputs in negative ways. This implies a concern within the design and subsequent script of competence and literacy (or lack) of the user.

[1] https://elm.perkinelmer.com.

In what follows we will address three aspects of the Elm sensor deployment that progressively emerged from the ethnographic fieldwork: data veracity and completeness; physical installation of the sensors; and usability, and anticipated response to the sensor readings. In detailing these three elements, we aim to move from a purely technical position, through a concern with the spatial aspects, to an appreciation of the social contexts of the sensor deployment exercise. We also reveal a "discovery narrative", borne of following the actors (academic staff, installation staff, and council staff) and those actors reflecting on the process of technology configuration and deployment.

2.1 Technical Aspects: Data Veracity and Completeness

While the operating manual of the Elm sensor implies that there should be no data loss, because the sensor stores any information and transmits it when there is an adequate GSM connection (Williams et al. 2015), it was found in the testing of the sensors that data dropout was a common occurrence. The issue of data loss became relevant when calculating the average readings from each sensor.

The following diagram shows the connectivity of 19 sensors over a 44-day period. It should be noted that the sensors were not installed in the city at this point, but were installed together on the roof of one of the university buildings. Put another way, the potential variability in signal strength and connectivity due to variation in GSM coverage and interference due to changing physical conditions (such as traffic density) was not seen in this early stage of the installation process.

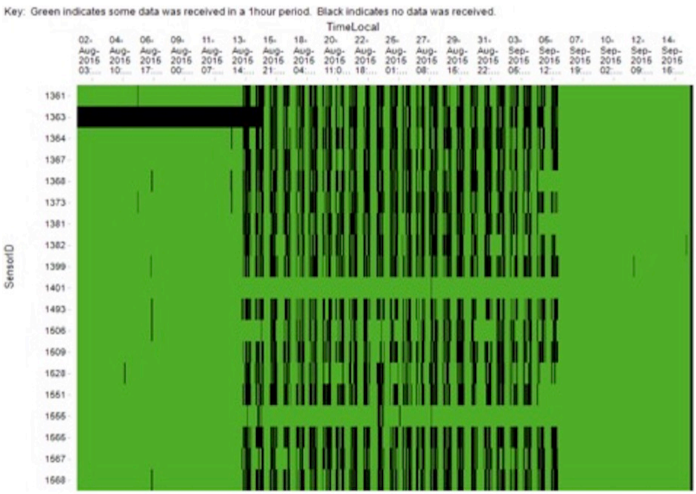

Figure 1 – Data transmission of the Elm Sensor array. Source: staff member.

In the above figure (Fig. 1) the black sections indicate hour-long periods in which no data was transmitted. While certain periods, notably from the 2nd to the 13th of August, saw relatively uninterrupted connectivity (aside from one sensor – 1363 – that appeared to be offline) the period from the 13th August to the 6th of September saw a great deal of connection loss.

The sensors collect (and transmit) information every 20 seconds, so this means that in those periods coloured black, none of the three transmission points were successful. In the following figure (Fig. 2), we can see readings represented in units of six hours:

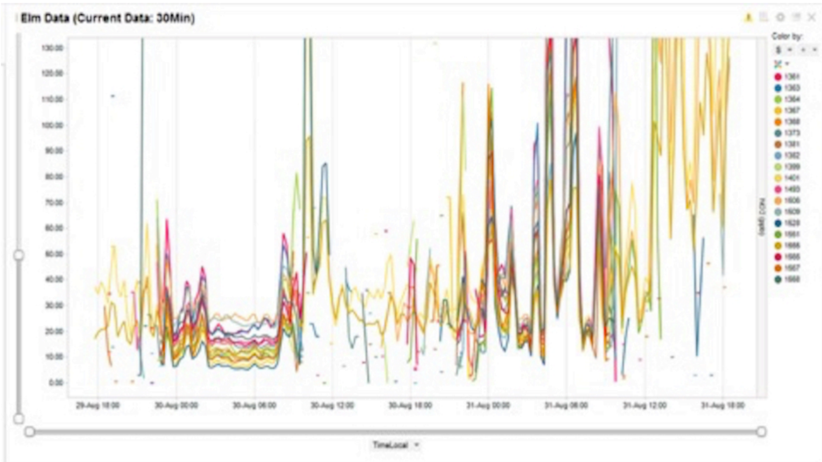

Figure 2 – Data transmission of the Elm Sensor array. Source: staff member.

The section between 30th of August, 1200 to 1800 hours has only two out of the 19 sensors transmitting continuous information. Such issues were dealt with pragmatically by the installers of the system. It was suggested that those periods in which there was data dropout would simply not be reported. Whether this would be indicated in the interface to the data was unclear (indeed, at this point the issue of data presentation took second place to data use, and calculation of an average figure).

2.2 Spatial Aspects: Location of Sensors

During the above-mentioned exercise in which the sensors were installed on a university roof top, planning for where the sensors would be installed in the city was underway. The requirement for a power supply led to a strategy of attaching Elm sensors to lamp posts. The existing positioning of lamp posts became a foundation for the choices made in relation to situating the sensors. A Research Fellow on the programme undertook a review of the city that combined lamp post positioning with the location of schools, care homes and businesses to figure through an optimum positioning of sensors based on positioning them near vulnerable individuals and businesses.

The following diagram (Fig. 3) shows the results of two of the mapping exercises.

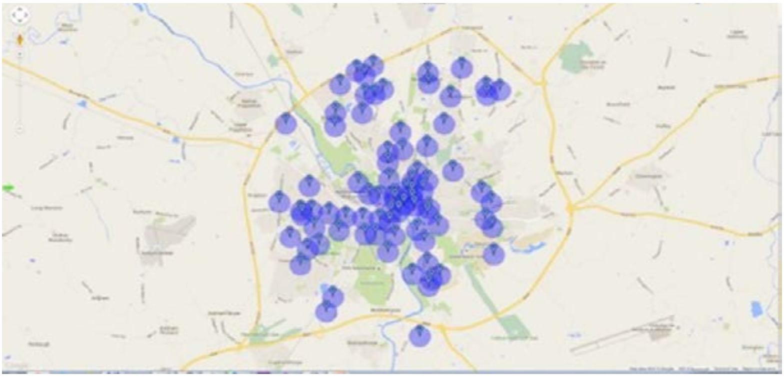

Figure 3 – Location suggestions for the Elm Sensors. Source: staff member.

In figure 3, the lamp post suggested relates to the physical location of businesses, care homes and schools. In the following diagram (Fig. 4) the positioning of lampposts was set against "vulnerable subpopulations". This was based on census data.

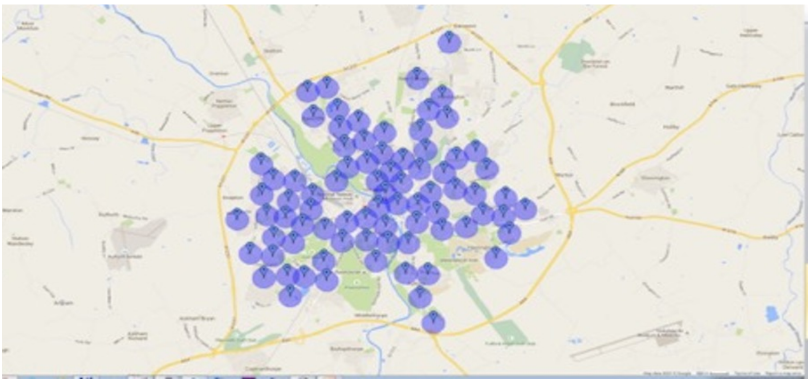

Figure 4 – Location suggestions for the Elm Sensors. Source: staff member.

It should be stressed that this exercise was a provisional preparatory exercise, and in the actual deployment seen since the preparatory work the sensors have been installed on a piecemeal basis, related to targeting areas with a range of interesting features, such as a mixture of housing stock, in combination with a school and park areas. This research based reasoning foregrounded the need to show that the sensors worked within a prescribed physical ecology. It also addressed a broader issue of availability of sensor units. The large-scale strategy imagined that one hundred sensors would be available at the same time. Given the variance in readings across the units, it became clear that this availability would be at least curtailed, and potentially undermined, by faulty (or at least variably reporting) units.

The Elm sensor did not have a location in its initial design. As a unitary device that functions within a network of devices, the Elm sensor's design was concerned rather with its laboratory functioning, rather than its real-world functioning. This is often the case in technology design. A device developed in the R&D department of a company, rarely undergoes usability testing, except in terms of its simple interface functionality. It is not, in this sense, field tested or put into use in everyday settings; until, that is, it is released for sale. Recent instances of battery fires in the Samsung Note 7 (http://www.bbc.co.uk/news/business-37253742 – retrieved September 1, 2017), for example, stand as examples of this failure to consider the social context of use. Elm functioned appropriately under the ‘perfect conditions’ of the laboratory, but as we know such contexts are without extraneous factors such as environmental conditions, imperfect GSM signal, or variable power supply.

As mentioned previously a key aspect of the first design of the sensors is that they were not independently powered (either through a battery, or solar power cells). Therefore, deployment was strictly limited to places where power-supply was already present. In the case of the test rig on the university campus this could be organised by extending a building’s power supply to the roof. However, ‘on the street’ the logical answer was to position the sensors on lamp posts. Further delays were encountered in negotiating with those in charge of lamp post installation and maintenance for various reasons. First, there was the issue of who would pay for the changes, second the likely effects on the structural integrity of each lamp post needed to be independently established, and finally a means needed to be found to account (and potentially pay) for the power used. In relation to what became known as the “seven up, ten down solution” – where a power line would be run up the outside of the lamp post to the lamp at the top and then fed down the centre of the post to the power supply at the bottom, rather than drilling into each lamp post at the point at which the sensor was attached – the issue of sensor height became important. This, as it turns out, is a non-trivial issue for the readings gathered. Lamp posts are typically positioned on roads, and the traffic on roads varies dramatically, not only by location, but also by time of day. In addition, the likelihood of standing traffic would need to be taken into account. The lower the sensor is to the ground, the more likely that higher readings would occur. However, taken too high and the comparability to pollution inhalation by a walking person would be obscured. It was decided that the seven up, ten down option (which assumed a position three metres above the ground) was inappropriate due to potential vandalism, and hence an independent structural analysis was undertaken. So here we can see a range of technical and social issues that intertwine and potentially impact each other. These are, therefore, socio-technical issues, neither merely social nor merely technical, but a combination of both.

Here then we have one key issue of social spatial and material configuration – the marrying of sensor position to the positioning of human pollution receptors. The original script of "awareness", "empowerment" and "informed decision" of the sensors (seen in the quotation above) was premised on the idea that they measured the pollutant levels experienced by a typical human – or at least within reasonable tolerances, but the material and practical instantiation of the positioning threatened to undermine any such a script.

We can see then that such issues as power supply and height positioning, while premised upon technical issues quickly became spatial and material concerns. Such elements of the installation were not part of the original design, and hence in a sense the devices were unprepared for real world deployment. What ensued in the case study was far from a simple matter of technical problem solving, instead it entailed contending with institutional and organisational factors, such as the rule and regulations governing lamp post maintenance, power supply payments, and ownership of the host systems. At one point, it seemed that the "lamp post department" (we never found out the correct name for whichever department was responsible) would veto our attempts to have the sensors installed. This reminds us that any technology is reliant upon the social and technical infrastructures already in place (Bowker et al. 2010; Dourish and Bell 2007).

2.3 Data Readings and Social Acceptance

Another apparently purely technical aspect of the Elm deployment was a comparison between the separate units. However, this quickly became a social issue, as the nature of the data variance was deemed to be giving an impression of dangerously high concentrations of pollutants. This is again an instance of projected sense-making, in that the project partners assumed they could put themselves in the place of the typical user, and anticipate their experiences and thoughts. As can be seen from the previous section on data dropout, each of the sensors transmits information separately. As part of the initial work done on the deployment, the sensors were located together to compare the reading that each was making against one another.

This can be best seen through the following graph (Fig. 5), which shows readings from three Elm devices set against an expensive city-based government monitoring station.

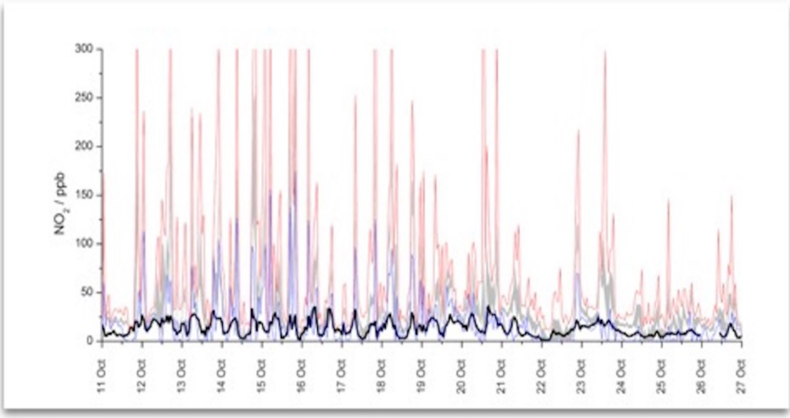

Figure 5 – Comparative readings from AURNAQM and 3 Elm sensors.
Source: staff member.

The lower thick black line shows the readings of NO2 from the Automatic Urban and Rural Network (AURN) Air Quality Monitoring (AQM) station run by DEFRA (The UK Department for Environment Food and Rural Affairs). The lighter red, blue and green lines are taken from three co-located Elm sensors. Not only do these sensors' readings show variance (although it should be noted they generally follow the same pattern of peaks and troughs), they also show readings that are a multiple of ten of those from the AURN station.

To put this in context, the hourly limits for NO2 are 200 μg/m3 (200 micrograms per metre cubed) according to EU and UK law, which relates to 106 ppb (parts per billion[2]). What this means is that the reading of 300 ppb given for some Elm sensors was nearly three times the requisite level.

Upon enquiry, the reasons for this variance spanned three different logics: 1. device function (quality of device; difficulty in air sampling); 2. location and context (contingent features of location of device); 3. atmospheric variability.

In the discussions that ensued between the partners of the project, it was decided that such figures would upset users and give a poor impression of the efforts to reduce air pollution in the area (the local council, with whom the YorkSense were partnered, anticipated hosting the sensor information on their open data platform – www.yorkopendata.org (retrieved September 1, 2017).

The net result of this observed variance was an effort to normalise the readings and calibrate the device:

[2] 1 part per billion equates to 1.88 μg/m3 at 25.

Normalisation involves transforming the data so that it is on a common scale. For example, if you have Elm and a reference unit data, you might transform both sets of data so they cover the scale 0 - 1. Calibration involves comparison of the Elm data with a reference instrument. Using the relationship obtained, you can add a correction to the Elm readings so that they give a sensible reading (personal email correspondence with project lead).

The following diagram (Fig. 6) shows the readings before and after the normalisation process occurred.

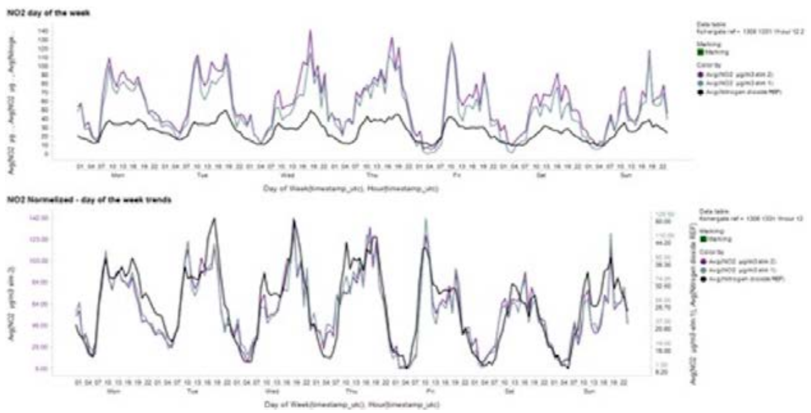

Figure 6 – Before and after normalisation of data. Source: staff member.

So, the sensor readings from the Elm sensors were manipulated so as to give more acceptable information. This is very common practice when shaping data such as this for public consumption. The idea that such readings might have been due to the functioning of the equipment, the location of the device, and atmospheric variance was not considered as an appropriate line of information and engagement with the public. This, it was anticipated, would complicate matters, and would lead to disinformation and confusion.

We would like to take these three elements and consider them through contemporary social theory and the conceptual work within science and technology studies.

3. Theoretical Discussion

In a foundation article in STS, Madelaine Akrich (1992, 206) takes up and elaborates a position in relation to social change afforded by technology – or what she calls the "partial reconstruction" of society and our knowledge of society – that takes neither a technologically deterministic nor social constructivist line. Instead it recognises that "technical objects participate in building heterogeneous networks that bring together actants of all types and sizes, whether human or nonhuman" by "mov[ing] constantly between the technical and the social" (ibid).

This is not easy to do, especially as such objects are commonplace and their workings are often hidden from view. She suggests the researcher should contend with a methodological problem, "if we want to describe the elementary mechanisms of adjustment, we have to find circumstances in which the inside and the outside of objects are not well matched. We need to find disagreement, negotiation, and the potential for breakdown" (1992, 207).

The Heideggerian notion of *breakdown* in phenomenology and human-computer interaction (Koschmann et al. 1998) is instantiated when a technology does not perform the way expected, or anticipated. In ethnomethodology instances of breakdown become a "perspicuous setting" (Garfinkel 2002, 186) for understanding naturally occurring breaches in practices (Garfinkel 1967), which reveal their workings and the efforts by users to re-establish a sensible scenario. In the case of the Elm sensor this occurred as the sensor moved from one social context – and concomitant network of actants of designers, commercial interests, and environmental scientists – to another, involving the imagined users, consumers and publics; and specifically, in the way the readings of the sensor were deemed 'incorrect' (the scare quotes are meant to convey the ambiguous nature of such a positioning) and inappropriate. This was during the deployment of the sensors. We treat this period as a naturalistic period of breakdown, and hence a methodological tool for revealing the workings of the device interwoven with the understandings of the device by relevant actors.

While the Elm sensor is itself made up of component parts, each of which has previously been calibrated and tested, it was received by the University as a stabilised technology. Preparation for its deployment in a real-world setting, however, "de-stablised" the technology by introducing alternative relevant social groups, and foregrounding its "interpretive flexibility" (Bijker et al. 1987, xlii; Pinch and Bijker 1984).

3.1 Inscribing Design through Scripts

Technology design is not a simple matter of incorporating functional elements in an artefact. It also involves building in various assumptions about who is going to use the device, and how it will be used. Akrich (1992, 206-7) asserted that, "when technologists define the characteristics of their objects, they necessarily make hypotheses about the entities that make up the world into which the object is to be inserted". This script is then deployed and becomes a pre-scription for the technology's use. "The technical realization of the innovator's *beliefs about the relationships between an object and its surrounding actors* is thus an attempt to predetermine the settings that users are asked to imagine for a particular piece of technology and the pre-scriptions (notices, contracts, advice, etc.) that accompany it" (1992, 208, emphasis added).

Key to Akrich's formulation of scripts, however, is the potential for an ongoing and continual process of *ascription*. This is what sets it aside from classical conceptions of designed-in purposes, in that there is not an end to the characterisation of uses for a device or system. In this case, ongoing processes include not only the subsequent *de-black-boxing* (Latour 2005) that occurred during deployment (initiated by the researchers), but also the effects of the networks of heterogeneous actants, including people (from the council, technical installers, and academic researchers) and artefacts (lampposts, power supplies) and materialities (streets, the city, and varying pollutants) detailed in section 2. This is what Woodhouse and Patton (2004) call "design by society".

Returning to Akrich (1992, 206), the script of a device not only delimits use, it also implicates responsibilities: "If most of the choices made by designers take the form of decisions about what should be delegated to whom or what, this means that technical objects contain and produce a specific geography of responsibilities, or more generally, of causes".

Extending Akrich's general point about design to this process of reconfiguration, we are interested in the shifting "geography of responsibilities" afforded by the configurational changes, particularly – as we will see – in relation to the competences (or lack of them) ascribed to imagined users of the informational outcomes.

This fits well with the notion of material participation of Marres (2012), especially as it relates to the political objective of civic engagement of the Elm sensor. In talking about the way environmental devices are explicitly implicated in forms of politics, Marres (2012, xii) comments, "material things are today deployed to enact a distinctive public form of engagement. In these cases, material objects, devices and setting are explicitly ascribed the capacity to enable political participation" they "wear their politics on their sleeve".

In terms of Elm, its imagined user base and use context implicates a set of political arrangements, in which – as we saw from the quote from Perkin Elmer above – the device enables, but also requires, the participation of members of the public. Key is the ascription of competence (or lack of) and hence literacy. Elm certainly wears its politics on its sleeve. While shaped in terms of creating awareness, empowering, understanding, helping, make smarter, and informed decisions, it is not difficult to hear the responsibility placed on users to be aware, form an understanding, and make smarter decisions – in short be competent and skilled users. The prescripted "user" is clear.

It is often the case within a technological deterministic argument that devices such as Elm are presented as bringing about change without the need to consider social arrangements. Such language obscures not only the social context, but also the requisite competences and responsibilities that such devices implicate. As Barry (2001, 127) points out "active, responsible and informed citizens have to be made". Grint and Woolgar (1997) talks about the "configuration of the user" through such processes. Configuration in this instance would seem to be oriented to an "informational citizen", who is aware, informed, and willing to make decisions. This in turn implicates a set of motivations, competencies, and behaviours. This fact leads us to consider issues of literacy.

Marres (2012) presents the history of efforts to engage the public in environmental concern, by first noting that it is apparent that the "informational citizenry", implicated in efforts to improve literacy, have largely failed to result in the recruitment of the requisite numbers of people. Informational literacy campaigns do not address the complexities and contextual aspects of social factors. Not only does informational literacy forget the contexts of technology installation and use, it also could be said that it is based on a "deficit model" of competence, in that it positions typical members of the public and lacking the requisite skills. The implication being that to become an engaged citizen requires a re-education of members of the public (or in this case a 'dumbing down' of the information). We want to argue that this position is too one-sided. It is the case that there are various competences required, but it is also the case that there are existing competences that such perspectives forget. These play into potentials for heterogeneous and alternate actor networks.

Rather than rejecting this history outright, Marres (2012, 5-6) goes on to say that "material participation does not involve stripping participation of its foundational, linguistic or discursive components", Instead, we would argue, literacy (and other discursive components) are interwoven with forms of action; a far more complicated scenario ensues in which reading information is mutually elaborative with design. Technologies simultaneously perform a particular user, and are performed by those users. So, in the case of Elm, participation is reconfigured by "turning everyday material action into an index of public participation" (2012, 3).

Marres takes these ideas a step further by being critical of contemporary moves within environmental monitoring, which are oriented to recruiting participants through the allure of simple interfaces and easily consumable information. Behavioural change through design initiatives are oriented to "involvement-made-easy" and "small changes" (2012, xiv). These function "without any significant appeal to their [the actors'] consciousness being necessary" and hence risk "removing initiative". Marres takes issues with such approaches, and advocates seeing the introduction of devices such as Elm as "experimental sites of material politics, a site where the political capacities of objects and environments are being actively configured" (2012, xv).

Marres champions *material participation* as an undervalued opportunity for new forms of public engagement. In relation to sensors this relates to not only the material agency of the particulates being measured, but also the material interaction with devices and systems by people themselves. There is, of course, an additional material element, which completes this pairing, that is the materiality of the physical environment. Person-device-environment form a triangle of relationships that in turn implicate a materially grounded and located set of activities. As Marres puts it an "interest in the role of material entities in the organization of citizenship" itself offers a renewed "sense of public engagement as an embodied activity that takes place in certain locations and involves the use of specific objects, technologies and materials" (2012, 7).

However, we would like to contend that such opportunities are potentially undermined if the operations of those materially-oriented technologies are obscured and obfuscated. We argue therefore that if the contextual details of the sensors' deployment (the necessity to choose installation points with lamp posts, the sensitivities of placement of the devices at certain height, and proximity to traffic) and the adaptations and manipulations of the generated data (through calibration and normalisation) are excluded.

In relation to Elm, we might say that Marres would be critical of efforts to remove the contingencies of their placement and the smoothing of readings through various data manipulations. Rather, we should see Elm as an opportunity to engender an "experimental site of material politics" (2012, 106) by allowing for questioning, knowledge development, and criticism of the devices and its outputs.

Building on the point of the mutual elaboration of technology and use, we turn to the educational literature of literacies to draw out, and critically engage with, the history of work on digital literacy. The plural form conveys the central theme of the perspective which dissuades us of a single understanding of literacy and advocates a multiplicity of distinct but interrelated forms. Again, we should emphasise that we are not claiming an individual competence model. Rather this pluralisation opens up both the concept of literacy, and problematizes its simple application to human-device relations. We agree with Marres' criticism of the formation of the informational citizen, but seek to extend her inclusion of the discursive and linguistic readings in design and deployment.

3.2 Digital Literacies

In the field of education there is a history of work concerned with digital literacy. This has, at different times, been referred to in different ways, including information literacy, media literacy, and technology literacy (Martin 2008). While such terms have led to a recognition of the socially embedded nature of such literacies, they are typically articulated such that a person's literacy can be measured, assessed and improved. That is there is a single linear conception of the more-or-less literate person. Such approaches have come under scrutiny through a concerted effort to engage with social concepts, especially in relation to the notions of practice and context, "we perceive literacy as a set of socially organised practices that make use of a system of symbols and of a technology to produce and disseminate it. Literacy is not simply knowing how to read and write a given text but rather the application of this knowledge for specific purposes in specific contexts. The nature of these practices including, of course, its technological aspects will determine the types of abilities associated with literacy" (Scribner and Cole 1981, 236, as quoted in Illera 2010, 51).

For Illera (2010, 50), practice and context implicate a processual approach, and simplistic notion of literate and illiterate are avoided: "The idea of practice […] changes the focus of analysis: no longer solely concerned with results, it highlights the relationship between the cultural (and technological) context and the forms of specific use adopted by the subjects. […] The gradual nature of literacy recognises that it is a continuum, one of competence, in which there are many positions and not just two categories (literate/illiterate)".

Yet for us, even these moves to situate practices of digital competencies don't go far enough. They still retain (as one might expect from an educational approach) a sense of (individual) measurement and deficit. One step towards an alternative is seen in the advocacy of the plural form of literacies (Lankshear and Knobel 2008; Illera 2010). The work on digital literacies not only reaches for the "myriad social practices and conceptions of engaging in meaning making […] that are produced, received, distributed, exchanges, etc., via digital codification" (Lankshear and Knobel 2008, 5), it also reveals the potential for competing literacies and the denigration of one type of literacy in the face of another. An example given by Lankshear and Knobel (2008, 8) is video game literacy, and they draw this out to implicate a far wider set of competing competences by speaking to the research cliché of "young people trapped in a literary remediation in schools whilst winning public esteem as fan fiction writers, AMV remixer, or successful gamers online". From here we might add digital literacies of online shopping (Davies 2008), participating in social media communication (Knobel and Lankshear 2008) and the ability to promote and market small businesses (Efimova and Grudin 2008). Erstad (2008) points to music remixing as a denigrated, or our terms disruptive, form of digital literacy (see also Pegrum 2011).

Once we move to remixing as a disruptive digital literacy, it is only a small distance to other more questionable literacies such as hacking, glitching and modding. Our argument is that it is exactly these forms of behaviour - positioned as one more set of literacies – that are key to data engagement and civic involvement (Townsend 2013). Indeed, understood as forms of creative engagement, these literacies take on a positive character, and one which has many benefits (not least that it encourages forms of playful and non-trivial engagement). They also entail active networks of actants (humans, devices, and software) whose place within any script is continual and challenging.

4. Experiencing Data

Couldry et al. (2016) sets out a phenomenologically situated position in relation to the agency of the algorithm and the human. He advocates a turn to an understanding of *social analytics*, the study of the practices of sense-making applied to contemporary forms of data analytics and presentation: "A social analytics approach – more precisely, a sociological treatment of how analytics get used by a range of social actors in order to meet their social ends – aims to capture how particular actors reflect upon, and adjust, their online presence and the actions that feed into it, through the use of 'analytics'" (Couldry et al. 2016, 119).

What we get from such discussions is a sense of the agency of persons, and the crediting of them with a range of competences that could easily be denied and avoided. In addition, the obfuscation of various elements can lead to a one-sided visibility which blinkers the user and undermines her viewpoint.

As Couldry (2016, 120) points out, "while the mutual intertwining of human and material agency is hardly a new insight (Pickering 1995, 15-20), it acquires special bite when analytics' operations are frequently opaque to non-experts and hard for them to control, even if they do see them at work; such tension is increased for those social actors who are orientated to goals that are distinctively social, such as community organizations, charities, and civil society actors".

Put another way, it is bad enough that various aspects of the Elm sensors are opaque (let alone manipulated), but when there is a motivated public, such as those concerned with air quality in a certain area, such opacity is clearly a problem. While conceptually Marres, Knobel and Lankshear, and Couldry come from different positions, and hence engender distinctions and potential contradictions in relation to their world views, the formulation presented here aims to navigate a path from material participation through the multiplication of competences as interwoven in the emerging script of the device, to an advocacy of person-centred intervention through creative agency. By favouring an ethnographic approach, which follows the actors in the installation, testing and configuration of the technologies, we are able to respond theoretically to the issues and concerns encountered. Such sensitivities benefit constructively from moments of breakdown and the subsequent activities to normalise the technology. Yet, they also lead us to (re)consider digital literacy as implicated in the construction of the scripted actor by relevant stakeholders. In turn, we continue a critical line in relation to such individualistic notions of literacy by advocating a continuance of breakdown through the embracing instead of apparently disruptive literacies. This is meant as a resistive political position, as well as an optimistic directive for future technology developments. Such combinations of method and theory, therefore, are necessary when responding to such complex, and embedded, contexts.

And so, what we have is a situation in which a commercially developed device, that has undergone testing in laboratory conditions, is deployed in a real world setting. The device is judged to be unfit for deployment due to inconsistent readings across individual units, and hence adjustments are made to the readings to 'normalise' them. In addition, knowledge of the real-world settings, which includes the placement of each device in a different, yet specific, location requires further adjustments in relation to accounting for contextual features, such as the height off the ground, and the likely architectural features of the city which might produce distinctive environmental conditions (such as the collection of particulates due to 'eddies' caused by building positions and tunnel like features of houses and shops).

The question becomes whether changing the data in this way is a necessary added step in the deployment of the sensors. On one side, we might say that we have revealed the processes of data production, what Ribes and Jackson (2013, 148) call a "complicated ontological choreography, as scientists and technicians work to make data 'the same' in a changing ecology of technologies, organisations, field sites, and institutional arrangement". At the same time, we have revealed the obfuscation of those very processes in the attempt to produce a 'perfect' outcome based upon calibration and normalisation.

4.1 Opening up Creative Practices

The notion of error presupposes a perfect reading or outcome. As Lisa Gitelman (2013) and other point out in "raw data" is an oxymoron, far from there being a perfect objective outcome, objectivity is itself a product of situated practices within applied scientific disciplines.

In our case, the objectivity of the data is a key issue in relation to dealing with the positioning of the sensors in particular locations. The placing of the sensor on road side lamp posts introduced unwanted contextual factors. It turns out that the data was never objective and never raw.

We can see that such instances open up possibilities for alternative engagement with information, "Error, as errant heading, suggests ways in which failure, glitch, and miscommunications provide creative openings and lines of flight that allow for a reconceptualisation of what can (or cannot) be realised within existing social and cultural practices" (Nunes 2012, 3-4).

Error opens up the data as created and fallible. Such natural breakdowns implicate deliberate breaching and practices of creative engagement with data. Contemporary conceptions of "hacking" and "glitching" are turning to an appreciation of their creative qualities, and certain authors are advocating such notions as a means to characterise creative engagement, and by extension forms of participation and political action.

For example, Townsend (2013) combines big data with civic hackers into a conception of smart cities. In a wide-ranging commentary on the future of sensor enabled urbanscapes, he comments that "every civic laboratory needs a physical and social support system for hackers and entrepreneurs to experiment within" (2013, 301).

We argue here that far from an errant feature of an unscripted set of characteristics, the variance in readings that occurred with Elm could be a means to enable an engaged public.

First it can open up the functionality of the device. A realisation that each device can give different readings in the same setting, opens up the possibility of a series of artefacts that differ from one another. Far from a replica of another, and far from the possibility of true replication of components into a single possible outcome, the Elm sensor becomes a material artefact that is realised in a particular context at a particular time. We are not disturbed by such notions when we think of different individual humans perceiving the world in different ways (such as subjective notions of the weather being poor, or the temperature being too cold) so why should we not credit measuring devices with such a multiple and perspectival quality.

Second, such a perspectival quality opens up the notion of context. Where a device is placed, how it came to be there, and the conditions in which it finds itself are of course variable. Again, we have no problems in understanding the varying contexts of the city; for example, that certain streets will be more or less shielded from the effects of pollution, radiation, and precipitation. So why would we imagine that it is obviously the correct operational logic to remove such contextual aspects from the recording device? Do we imagine that the general public do not understand, or appreciate, or indeed continuously work with and through such contextual features?

Third, by allowing for an appreciation of the perspectival and contextual nature of the devices, we are further allowed to appreciate the functionality of each device and its agentic qualities. Each device functions within a context to produce a series of readings which are imperfect, but meaningful. They are interpretations of the air quality (or should that be qualities) in their immediate surroundings. The device becomes an interpreting machine and not a recording machine.

Finally, a recognition of error, glitch, and breakdown license forms of critical and creative engagement with information. This in turn might inform a type of open data that promotes discourse, questioning and debate. Such openings up could encourage and require new understandings and competences, new forms of (potentially disruptive) digital literacies. By expecting the typical user to content with the complexities of environment data we might encourage the development of new skills in reading such data.

Our argument is then that far from correcting the errors and normalising the readings for the physical contexts of deployment, such features would enable a more creative and open engagement with the devices as socially situated technologies. We should maintain the *data frictions*, to use a term from Edwards et al. (2011) that recognises and embraces the ad hoc, incomplete, loosely structured, and mutable nature of data.

5. Conclusion

This article has used the case study an urban pollution sensor and its real-world installation to address key issues in relation to the contingencies of installation and the characterisation and taken for granted manipulation of the resulting data. By following the installation process, contextual features such as the requirement for infrastructural support for a power supply, and the resulting positioning of the sensors close to pollution producing vehicles, were used to describe the continuation of the design script of the sensors and argue for its extension into the practices of installation. Recognition of contingency by the installation team, and the variance in readings obtained led the team to manipulate the data, through standardisation, configuration and normalisation. Such processes were deemed necessary and indeed a requirement for future installation periods. We took an alternative view in relation to the experience of environmental data by potential users. Rather than smooth the data, we advocated a perspective premised upon opening up the physical, cultural and ecological context of use, so as to engender the emergence of new digital literacies. This line of reasoning recognises the changing nature of digital literacy, with the emergence of new competences and skills, and argues that nurturing such literacies could provide a means to engender a politically engaged participation in environmental data, and in turn lend a complement to the notion of data-driven cities – the creative engagement of data by citizens. In this way, we hope the article contributes the debates and discussion of the relationships between data and users in the city context.

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How to Design the Internet of Buildings?
An Agile Design Process for Making the Good City

David Hick
TU Dresden (DE)

Adam Urban
TU Dresden (DE)

Jörg Rainer Noennig
TU Dresden (DE)

Abstract: In the context of data driven cities, this paper introduces the notion of an "Internet of Buildings" (IoB), and discusses the potential of connected devices, sensor networks and data analysis to support the purposeful design and development of a livable, well-designed urban environment. The key argument of this paper is that today's Internet of Buildings (IoB) permits the collection and analysis of rich data sets on users and usage, on building and city performance, thereby providing a reliable basis for design decisions and strategies that not only improve design processes, but also enable a more user-oriented, participative and human-centric approach. In addition, this article argues for a responsible and reflexive usage of data generated in living environments and for data literacy in the context of urban design and development. The key challenge addressed in this paper is how to translate urban data into design knowledge. To provide an answer to this important question, this article introduces a new methodology that links urban design, urban data, and the operational modelling of cities to an evidence-based, agile urban development process. On that basis, the article introduces the two tools of "BuildingID" and "UrbanOperationsModel" (UOM) – key instruments for data-based development and oriented towards the "good city" of the future.

Keywords: Internet of Buildings; cyber-physical systems; urban data; building information; urban operations.

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Corresponding author: David Hick, TU Dresden, School of Civil and Environmental Engineering, 01062 Dresden, Germany. Email: David.Hick@tu-dresden.de

1. Introduction

Approximately a decade ago, the shift towards information society and ubiquitous data technology originated the term "smart city". This debate is supported by various predictions foreseeing a dramatic increase in the

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number of intelligent and networked objects in an urban context. Gartner Symposium ITxpo[1] has announced a 200% increase by 2020 with respect to 2016, while companies like Cisco announce even higher figures. A central tenet of the Smart City, largely technology driven, is the integration of ICT systems for creating synergies and improved urban quality of life (Batty et al. 2012, 483-518). Yet, multiple urban challenges accompany this development: how can Cyber-Physical Systems (CPS), the Internet of Things (IoT)[2] or the Internet of Everything (IoE)[3] meaningfully support the development of well-organized urban systems with a high quality of living, engagement, and social cohesion? So far, IoT applications are driven by the IT industry and digital business world. Urban environments and operations have only recently come into focus as strategic fields of application.

To highlight this new trend towards networked buildings and urban spaces, we introduce the term "Internet of Buildings" (IoB)[4]. We maintain that it is necessary to establish a focused debate on connected buildings and urban technologies from the perspective of an urban planner and architectural designer, given that digital technologies will have a direct impact not only on visual appearance, on functional infrastructures of buildings and cities, and on the operations and performance of cities, but also on professional key practices such as creative design, concept-creation and planning. Evidence-based practices are emerging that characterize design and planning activities as services, based on urban and building information, and on public and institutional data.

A telling indication can be given by the example of Sidewalk Labs, a Google/Alphabet spin-off[5]. The mother company clearly anticipates profitable opportunities in the field of digital urban services. Among other powerful applications and technologies, it has established urban mapping and home sensing systems, as highlighted by the acquisition of the sensor

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[1] See http://www.gartner.com/newsroom/id/3175418 (retrieved March 22, 2017).

[2] IoT is the vision of a ubiquitous digital machine to machine network connecting a high amount of everyday 'smart' objects embedded with sensors and processors to collect, exchange and combine data. There is no common consensus on how to systematically transform the data generated into social or economic value.

[3] The 'Internet of Everything' is an extension of the term 'Internet of Things', established in 2013 by IT company Cisco. In contrast to the Internet of Things, it implies not only connections of computer systems, but also of people, and the usage of behavior information measured by smart gadgets (cf. http://ioeassessment.cisco.com/).

[4] IoB consists of systematic and hierarchical structures with a clearly defined goal. It is a scalable network of relationships between quarters, streets, buildings, apartments, social life and quantitative physical factors like climate and air/water quality, aiming to get a profound understanding of the complex interplay of urban life. IoB can be considered a subordinate component of an IoT infrastructure.

[5] See https://www.sidewalklabs.com (retrieved March 22, 2017).

company Nest in 2015. Now, Sidewalk Labs is creating platforms for urban analysis based on data collected via these services. Apart from the specific urban services already up and running (e.g. optimizing traffic and transportation flow), the company is expected to commence experiments in data-driven urban design and city management with full-scale test projects soon. This is in line with large-scale digital city experiments such as WeSense by the Amsterdam Institute for Advanced Metropolitan Solutions[6]. This integrated data platform maps citizens' perceptions, use and evaluation of the public environment in Amsterdam. Another indicative project is City Keys (2017) which defines citizens' needs, analyzes results, and generates design recommendations by way of using performance indicators. These, in turn, are informed by sensor data from large urban areas in Europe. Also of note in the aforementioned Dutch city is the world's largest data bank of Smart city projects, the Amsterdam Smart City Platform[7].

Despite their rapid development in the field of ICT, Smart City projects and activities have created few links to the classical domains of urban design, architecture, and spatial planning in relation to procedures and methodologies. There is a surprising disconnection between the emerging digital city with its ubiquitous ICT components on the one hand, and the traditional design and planning processes for the physical city on the other hand. While new communication and information technologies gain ever more importance in personal and social life, aspects of urban life such as building construction, the public realm, and the provision of social or cultural facilities remain central concerns of the citizenry.

The authors perspective derives from a formal architectural training in various academic institutions (Germany, Austria, Japan, Poland, Czech Rep.) and design practice at an international level, ranging from architectural competitions to construction projects. With the exception of design tools like CAD, parametric design software and Building Information Modelling (BIM), the practice of urban and architectural design rarely integrates “smart” IoT or CPS technologies[8], which are traditionally not regarded as components in conventional design practice or education. We observe two directions; the first seeking to digitalize the built environment versus the main second direction continuing to revere human intuition and aesthetics as the sole methodological instruments of design. This latter direction is based on the principle that architecture is a discipline between science and art, and which can only be truly understood by professionals. Few research institutions actively engage in cross-disciplinary research combining design and IT (e.g. MIT Media Lab, HCU City Science Lab or the Institute for Computational Design and Construction of TU Stuttgart).

[6] http://www.wesense-app.com/wp-content/uploads/WeSense_artikel–energie–spektrum_en.pdf (retrieved March 22, 2017).

[7] See https://amsterdamsmartcity.com/ (retrieved March 22, 2017).

[8] One example is the ‘Smart Home’ promoted by huge technology companies like Samsung or Bosch.

Consequently, the greater part of the profession resists current developments concerning advancing digitalization and automation. Perusing the latest architectural journals (such as "Bauwelt" 20/2017, "Detail" 10/2017, "Architectural Review" september 2017 and "Arch+" 229) there is a disproportionally small amount of discussion on ICT in the building sector.

As a result, the approach presented in this paper attempts to connect the domains of data technology and data science with planning and design sciences. The central question is how to inform and support user-oriented design work at the urban scale with data acquired from buildings and public spaces. In other words: how to derive qualitative design decisions from data collection and analysis?

As a starting point for the creation of a methodology that comprehensively uses urban data in urban design, we hypothesize that the goal of urban design and development should be the "making of the good city". Following Jane Jacobs (1961), Ray Oldenburg (1999) and Edward Glaeser (2011), a good city can be summarized as a multitude of rich, lively, adaptable and organically developing places. Its structures and spaces grow steadily and incrementally, and possess the capacity to respond to the changing needs and emotions of its inhabitants. The development of historical cities with high urban quality (e.g. Italian Renaissance towns like Florence or Siena) is in stark contrast to current ad hoc developments, which often result in generic neighborhoods with low urban quality, uniform typologies and building patterns. Rapid land development and speculative investments have replaced the organic processes of urban self-organization and construction. Due to the financialization of the urban environment as a means of private property management, the social, emotional, and cultural needs of residents and inhabitants as key users of cities are often insufficiently respected. Due to well-established processes in real estate business, large districts are developed in a short timeframe without reference to local culture, history, or society. This leads to disconnected, insufficiently integrated urban quarters with low quality of life over long-time spans.

As a counter-reaction, however, alternative approaches such as incremental and participative planning have emerged, a trend that can be supported by advanced information and communication technology (ICT). For example, a Horizon2020 project called U_CODE Urban Collective Design Environment[9] will deploy a participatory platform for the purpose of co-creating urban environments on a massive scale enabled by digital technologies. Here, urban designers, architects and developers will collaboratively design and communicate projects with the various public stakeholder groups.

In ancient Greek towns, the emergence of agoras triggered communication between the citizens, pushing forward the public and democratic debate. Habermas (1989) calls public areas where social life comes together

[9] See http://www.u-code.eu/ (retrieved March 22, 2017).

as the "public sphere". Correspondingly, Oldenburg (1999, 22) defines those areas as the "neutral ground upon which people may gather", calling them "the third place", with the first place being "home" and the second "work". The main activity on neutral grounds is the informal conversation between citizens that forms a collective understanding of society, innovation, and diversity, as well as the "formation of public opinion, conference about matters of general interest or debate over general rules governing relations" (Habermas 1989, 27). This kind of social gathering forms the basis for raising quality of life in cities. Through public deliberation, factors defining quality of life like recreation areas, functioning infrastructure and a vibrant economy can evolve.

There are numerous examples of neutral grounds in different cultures, e.g. the French bistro, the German beer-garden, the English pub or the American main street (Oldenburg 1999). These examples show that not only actual urban places, but also business ventures can enable the public sphere. Historical towns like Siena or Florence developed a multitude of (third) places triggering the growth of a diverse society with complex urban interplay between voids and buildings. This process must develop over time and cannot be set up in ad-hoc developments. The prerequisite is the acceptance of those places as neutral grounds by society. Bridging the gap between the historic and the contemporary town we believe that "third places" necessarily do not need to be physical. Rather, they can be digital, and more importantly for future urban development, a combination of both. This fusion of digital and physical neutral ground can be defined as "hyperlocal forums".

Current digital urban infrastructures and algorithms model citizens mainly as "living sensors" or network clients within a larger cyber-physical system, which represents a narrow understanding of the interplay between human activity and the quality of the urban environment (Farías and Blok 2016). Data-driven urban design which works towards the Good City maximizes not only the gains on the side of technology vendors, but also expands the reach of political power and the roles and responsibilities of the social groups, neighborhoods, and communities that need to be defined with respect to urban data generation, governance, and utilization.

The key approach taken here may be called creative urban data literacy, as it implies the practical and creative usage of self-generated urban data by the local community. The goal is to pave a way towards hyperlocal forums that connect and empower citizens as individual data entrepreneurs, creative urban hackers, or service providers. Also in digital terms, cities need to be developed on a district-by-district basis, leading to a replacement of the neoliberal top-down approach. The "right to infrastructure" (Corsín Jiménez 2014), as derived from Lefebvre's "right to the city", also implies new forms of digital collaboration, as exemplified by fab-labs or hack-labs, for example. Such infrastructural enablers empower bottom-up development, or soft digital urbanism. Through the systematic extension of know-how and information, the simplification of construction processes and juridical frameworks, citizens can be enabled to design and build cities on the basis of their own data. Collective experimentation with urban data renders cities as socio-technical assemblages open to contingent political contestation (Jiménez 2014), created through digital participation and knowledge production, and its subsequent validation in terms of urban products and services. The concept of "urban learning forums" (McFarlane 2011) outlines such possibilities in urban planning. Ideally, such methodology might lead to self-sufficient communities even at the level of data-production and consumption, with a hybrid forum serving as a place for knowledge exchange between experts and lay people (Callon, Lascoumes and Barthe 2009).

Accordingly, the scheme proposed in our paper builds upon the idea of a hyperlocal community, or a "Quarter Community" which, via digital technologies, is able to recognize and interpret subjective indicators such as procedural constraints for urban development. Here, subjective and hybrid data generation that does not reduce citizens to passive objects of digital technology forms the core of the urban data community. We regard the human subjective dimension an enhancement of the objectivized, Euclidian urban space which still forms the basis for most conventional architectural and urbanist representations (Latour and Yaneva 2008).

2. Data for the Good City

2.1 The Livable City

The "good city" implies qualitative goals for urban development. Allan Jacobs and Donald Appleyard have defined a value framework for the good urban environment with seven characteristics: livability, identity and control, access to opportunity, imagination and joy, authenticity and meaning, open communities and public life, self-reliance, and justice (Jacobs and Appleyard 1987, 115-116). This indicates that a Good City shall not be equated solely with a Livable City, as the latter appears to be a subcategory among other influential values. A good urban environment balances these goals on both an individual and collective level (Jacobs and Appleyard 1987, 112-120).

For livability, there is certainly no universal definition. Charles Landry (2000, 21) points out that the inhabitants of Northern cities have higher standards of living and therefore can consider clean air, public realm, or cultural facilities as key quality of life factors for livability, whereas in poorer places quality of life is related to work and the education system, or infrastructure. Taking this relativity into consideration, indexes for livability (Quality of Life) have emerged in recent decades, measuring livability and its associated factors.

2.2 Quality of Life – Objective and Subjective Indicators

Quality of Life indexes utilize different benchmarking procedures to rank cities and countries. Relevant indexes for this approach are the Human Development Index from the United Nations (HDI)[10], the Happy Planet Index from the Economics Foundation (2016), the Morgenstadt Index (Tomorrow's City Index) from the Fraunhofer Institute (IAO)[11], and the ISO 37120 from the World Council on City Data (WCCD)[12]. This last index is the first to work on the development of an international standard applicable to all cities. Both the Morgenstadt Index and ISO 37120 are useful for determining data for the "Good City", as they collect qualitative city data at the local level.

The Morgenstadt Index was created through a detailed investigation of publicly accessible indicators to form a holistic picture of the future viability of a city, and as a first basis for an in-depth analysis of urban neighborhoods. The proposed indicators cover four basic pillars on which a city must be based: quality of life, resilience, environmental protection and innovation potential. These pillars were broken down into 28 detailed indicators informing quality of life, and evaluated according to their absolute and relative values.

The ISO 37120 index by WCCD encompasses an international network of innovative cities using open data to create a platform that maps standardized urban metrics. It has the aim of pushing innovation forward and envisioning livable cities. Here, the indicators are categorized into 17 themes on city services and quality of life, such as environment, economy, education, and transportation.

Our research group has analyzed these indexes to determine which relevant data need to be collected and processed to inform the design and development of the "Good City".

These indexes and indicators gave useful indications on which urban data to collect and analyze, but they do not fully indicate the dynamics and progression of urban areas. The indexes are very global in nature; they measure society as a collective, but do not represent individual subjective perception. Quality of life and well-being, however, need to be related to dimensions on which an individual's living conditions can be measured, which may range from rather objective indicators (e.g. economic well-being, human capital) to more subjective indicators (e.g. social capital, personal satisfaction) (Giap, Thye and Aw 2014, 178). To assign to these hard-

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[10] Human Development Index (2016) [United Nations Development Programme], http://hdr.undp.org/en/2016-report/download (retrieved March 22, 2017).

[11] See the Fraunhofer Institut für Arbeitswissenschaft und Organisation, http-://www.morgenstadt.de/de/loesungen2/loesungen_staedte/morgenstadt_index.-html (retrieved March 22, 2017).

[12] See the World Council on City Data Foundations, http://www.dataforcities.org/wccd/ (retrieved March 22, 2017).

to-survey subjective data a higher impact, individual feelings concerning urban surroundings (joy, imagination, opportunity) require a better definition and description, such as through explicit measures for identity, diversity and social network dynamics (Landry 2000, 21).

Combined subjective and objective indicators which comprise both individual and collective experience provide for a meaningful utilization of urban data for the design of the "Good City". Although technologies for the collection of individual subjective information are still in their infancy, such urban data will represent city dynamics on a higher value level, and thus positively inform urban interventions. Collected and analyzed by Internet of Building technologies, their very value may arise from short-term (soft) spatial interventions as well as from long-term, permanent deployment. In both cases, they supply the development of urban areas with user experience and citizen knowledge. "Livehoods"[13] is a current example for mapping social dynamics, structure, and character through the analysis of users' behavior data in diverse cities. Here, the aim is to observe patterns in locations across the city to map different dynamic areas using social media check-ins. Accordingly, the hypothesis is that an individual Livehood's character is shaped not only by objective data, but also through the subjective behavior of citizens.

3. Key Questions

We have developed our methodology for data-driven urban design with three questions in mind:

- *Identification:* Which data are relevant for designing good urban quarters?
- *Acquisition:* How to systematically collect relevant data in urban environments?
- *Intelligence:* How to derive design knowledge from collected data?

3.1 Identification: Which Data Are Relevant for Urban Design?

We examined the Morgenstadt and ISO 37120 indices and devised a comparative representation. Based on relevant urban design categories, all related information from the indexes were assembled into one table. The table has been extended by further data, not yet covered by these indexes like food quality to mirror broader economic and social relevance in the districts[14]. The resulting shortlist of key data to be collected from urban

[13] http://livehoods.org (retrieved March 22, 2017).

[14] See Government of Canada, Agriculture and Agri-Food http://www.agr.gc.-ca/eng/industry-markets-and-trade/statistics-and-market-information/agriculture-

and building environments can serve as a basis for decision-making in urban design and planning (see Table 1). The table is divided into the City Data section which comprises information referring to the natural and artificial environment collected with quantitative methods (e.g. statistics, remote sensing, observations) reported as values or numbers, and the Individual Data section which comprises relational information on individuals and communities connected to their immediate environment collected via qualitative methods (e.g. surveys, questionnaires, interviews, gamification). Both data types are interrelated and can be juxtaposed. To get more detailed insights, both data types (City Data & Individual Data) can be recombined: e.g. combining data about "Square meters of recreation & green space" with "Individual perception about the atmosphere of recreation & green spaces" could lead to the new data set "Efficiency of distribution of green spaces in a city". Furthermore, the combination of the juxtaposed data sets "Number of businesses" with "Individual impressions about availability of businesses and services in a city" could lead to the data set "Diversity and fair distribution of businesses and services in a city". Recombination and mining for data relations will be necessary to approach a comprehensive understanding.

3.2 Acquisition: How to Systematically Collect Relevant Data in Urban Environments?

A major challenge for data-driven urban design is the definition of appropriate sources from which design-relevant data can be collected. Thus, we have further differentiated data resources according to their dynamics. First, there are resources like municipal archives holding data collected and structured over long periods. Second, there are streaming data of events and processes, such as comments on social networks or real-time mobility data.

A metaphor for stored and structured (Big Urban Data) data collection is the so-called data lake which constantly accumulates data, having a physical limit and time delay. In contrast, the real-time data stream (Smart Urban Data) resembles a river whose items pass by quickly and disable long term storage or permanent observation.

On a tentative basis, Table 2 shows data already available (marked green), data that are only available for authorities, like police or city departments (marked yellow) and data that imply technologies not yet developed (marked red).

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and-food-market-information-by-region/europe/market-intelligence/consumer-profile-germany/?id=1421933900883 (Retrieved March 22, 2017).

	City Data (Objective Data) Examples of data sets collected in a city with quantitative methods; reported as values or numbers	**Individual Data** (Subjective Data) Examples of data sets connected to the direct contemplated area of an individual; expressed as perception of the individual cognition area; collected with qualitative methods
Environment:	Squaremetres of recreation space & green spaces	Individual perception about the atmosphere of green spaces
	Fine particulate matter concentration / level of air pollution	Individual feeling about city's air quality
	Level of noise pollution	Individual feeling about the noise in direct surrounding
Economy:	Unemployment rate / average household income	Indivdual perception about monthly income
	Number of businesses	Individual impressions about availibility of businesses and services in the city
Population:	Percent of population that are child/adults/specific age	Individual impressions about the age, social and/or origin of people in social environment of a person
	Percent of population foreign born	Individual perception about the amount of foreigners meet in the direct social environment of a person
	Total number of households	Individual perception about the density of a city
Education:	Number of students completing school & number of higher education degrees	Individual impressions about the educational level of others in the social environment of a person
	Student / teacher ratio	Individual perception about teaching quality
Infrastructure:	Frequency of traffic jams	Individual perception about time spent in traffic jams
	Water quality and frequency of malfunctions	Individual perception about water waste in household/community
	Number & distribution of garbage collection points	Individual perception about quality of waste collection service
Governance:	Voter's participation in last municipal election	Individual perception about the work quality of local policy makers
	Number of police officers; Crime rate	Individual perception about the safety of the quarter
Transportation:	Number of personal automobiles	Individual need for a car
	Annual number of public transport trips per capita	Individual satisfaction about the quality of public transportation service
	Kilometres of bicycle & pedestrian paths or lanes	Individual impressions about the availibilty, usage and frequency of bicycle & pedestrian paths
Health:	Annual per capita expenditure for healthy (organic) food	Individual awareness about the need for healthy food
	Weight prevelance of population	Individual perception about health standard
	Number of doctors & health institutions	Individual satisfaction about the deployment of doctor's and about their quality of work (data source: work rating platforms)
Sustainability:	Total residential electrical energy use per capita	Individual energy consumption
	Use and development of renewable energy	Individual need for renewable energy
	Recycling quote (up-cycling) - quote of recycling for solid waste	Individual recycling habits
Culture:	Number of sport facilities	Individual possibility of access, quality and choice of sport opportunities
	Number of cultural spots and events	Individual possibility of access, awareness and perception of cultural offer
Building Function:	Age of a building	Individual perception about the appearance of the city
	Use of a building	Individual perception about the social environment settled in a building
Social Cohesion:	Number of social organizations	Individual perception about collective social engagement
	Annual number of direct democratic decissions	Individual possibility and willingness to participate in direct democratic decissions
	Number of cultural events	Individual perception about the local identity

Figure 1 – Urban data relevant for urban design and development.

	Stored & Structured Data Samples	**Real Time Streaming** Data Samples
City Data	**City's offices & authorities**	
	Urban Planning Office e.g. Development plans	**Smart Traffic Lights** e.g. Traffic / Pedestrian flow
	Cadaster office e.g. Collection of landowners	-
	Urban Cyber-Physical Systems (CPS)	
	Speed traps e.g. Cars number plates / Speed	**Buildings** e.g. Occupation, utilization
	-	**Urban Furniture** e.g. Climate / Pedestrian flow
	Municipal companies & services	
	Public transportation companies e.g. Fluctuation & frequency of passengers	**Public transportation companies** e.g. People's behavior
	Waste disposal companies e.g. Picked-up waste	**Waste disposal companies** e.g. Households producing different waste
	Public libraries e.g. Book turnover	**Public libraries** e.g. Frequency, room acceptance
	Private companies & services	
	Energy suppliers & Infrastructure e.g. Amount of used energy	**Energy suppliers & Infrastructure** e.g. Energy consumption
	Logistic post companies e.g. Number of delivered packages	**Logistic post companies** e.g. Delivery routes / Time needed for delivery
Individual Data	**Citizen's workshops**	**Citizen platform's**
	Participative planning workshops e.g. Citizen design ideas	**Co-Design Collaboration Platform** e.g. Engaged citizen groups
	Serious Urban Gaming e.g. Crowd design preferences	**Information / Idea Platforms** e.g. Idea collection for urban intervention
	Existing Platforms e.g. Social Media	
	Citizen Administration e.g. Opinions & feelings of citizen on Urban Environment	**Facebook, Twitter** e.g. Opinions & feelings of citizen on their neighborhood
	Urban Cyber-Physical Systems (CPS)	
	-	**Wi-Fi Kiosks** e.g. Wi-Fi user profiles
	-	**Home Sensors** e.g. Temperature, humidity, noise, air quality
	City's offices & authorities	
	Employment office e.g. Persons in full time employment	-
	Registration office e.g. Identification of citizens	**Registration office** e.g. Digital ID tracks
	Municipal companies & services	
	Schools & Universities e.g. Number of students graduating (dropout rate)	**Grading systems of schools and universities** e.g. Students' performance
	Private companies & services	
	Internet & mobile providers e.g. Number of signed contracts / Number of calls	**Internet & mobile providers** e.g. Location of cell phones
	Security companies e.g. Number of sold security products	**Security companies** e.g. Camera recordings / Door locking records

Figure 2 – Data resources according to their dynamics:
City Data vs. Individual Data.

The column “Stored and Structured Data” is of immediate relevance for city science due to its inferences of categories of urban quality. Open source platforms such as “Open City Smart”[15] allow for extensive collection and structuring of information, yet these formats and systems widely lack the standardization that would allow effective integration and processing of different kinds of (streaming) data. A serious obstacle is posed by the complex Graphical User Interfaces of these systems which require users, mostly urban planners, to work at the level of IT experts. From an urban design perspective, there is a clear need for data collection and analysis tools in combination with easy-to-use applications to support design creativity and decision making.

As a resource for the “Real Time Streaming Data” column, multiple sensor solutions already exist that allow real-time data collection. Many of these systems are designed for system maintenance, resource optimization, and technical control, but rarely for design intelligence.

Furthermore, data can be collected through surveying a community or society, such as in the “Quarter Community” proposed in this paper. Here it is necessary to first analyze the contexts and target group (e.g. via questionnaires) and to design an appropriate interface to address the community. This phase of (social) data acquisition is of key importance for the shaping of identity, and for identifying deficits as well as target qualities in the quarter.

3.3 Intelligence: How to Derive Design Knowledge from Data Collections?

In urban design and master planning, current practice is still widely based on subjective evidence. In most cases, only information relevant to planners is being considered in planning. Today, however, there is a chance to comprehensively collect data in response to actual needs. Data-oriented and evidence-based approaches provide an altogether new perspective in design disciplines. It is from here that the Internet of Buildings may find its biggest momentum. The multiplicity of available sensor systems (electronic, physical, social) in urban and architectural environments allow for a rich and target-oriented harvesting of design-relevant data. Systematically collected and structured, they form a reliable basis for design and decision making. However, the challenge of translating data into design is far from trivial.

How design intelligence can be derived from urban and environmental data is still unclear, despite a multiplicity of ongoing discourses on data-driven design. Focusing its research on this aspect, the WISSENSARCHITEKTUR Laboratory of Knowledge Architecture at TU Dresden endeavors not only to inform urban and architectural design, but also tech-

[15] https://wiki.osgeo.org/wiki/Opencitysmart (retrieved March 22, 2017).

nological development including sensors, communication media, and analytic systems. The method presented in this paper is a first step towards a design and development process that acknowledges data as a starting point for creative urbanist and architectural work, as well as for technological innovation.

3.3.1 Adopting Operations Modelling in Urbanism

In the past, many settlements and cities were built to last by the residents themselves. Today, however, cities and buildings have become objects of speculation with ever shorter expiration dates. However, cities remain places for the long-term production of cultural value, social wellbeing, and community cohesion. New urban operation systems are needed to maintain the creation and evolution of these urban qualities. From an operational point of view, cities can be seen as social enterprises that run a multiplicity of social, economic, environmental and other processes. Just as public or private ventures need to operate on sustainable plans, cities too must balance their forms of partnership, investments, expenditures, revenue streams, and value creation. It is important to highlight here that value does not necessarily mean maximizing monetary profit, but rather quality of life enhanced by technology and innovation. Cities are large-scale social ventures, and therefore not merely objects of short-term investment, real estate speculation, and fast-track profit.

On this assumption, we have adapted methods of operations modelling from the field of urban management and development and termed it "Urban Operations Modelling" (UOM). UOM is a method that models complex urban operations and services, and assesses them for their urban quality as well as their economic feasibility. While UOM may be applied to all kinds of urban services, this paper holds that urban and architectural design is a value-creating public service, which may yield greater benefits by utilizing urban data.

A key reference for the UOM is a creative method developed in the context of innovation management that schemes and validates operations and business design of enterprises (Osterwalder and Pigneur 2010). The method was re-modelled by its originators into a highly popular "canvas" tool (see Figure 3). As a decision-making tool, the canvas has become a new standard for policy makers, public bodies, and enterprises, as it is easy to comprehend and already works effectively at the prototype stage. The canvas gives a well-structured overview of all necessary items for planning a venture of any kind. The left-hand side ("Enterprise") and the right-hand side ("Market") are connected via a central column "Value Proposition" – a representation of the values created by the enterprise, and estimated by user or clients. The aspects on the enterprise section include Key Partners, Key Activities, Key Resources, and Costs. The parts on the market section define Customers, Customer Relationships, Channels and Revenue

Streams. The arrangement of the canvas enables rapid definition of the individual components, and also the quick outline of their connections. As a result, the canvas sheds light on the level of integrity of the venture at stake.

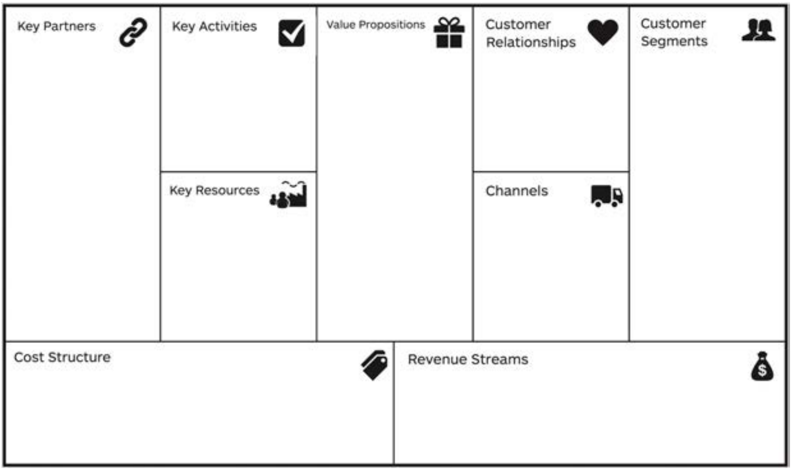

Figure 3 – The Business Model Canvas (source: strategyzer.com).

By viewing the components of the canvas from an urbanist perspective rather than an entrepreneurial perspective, the tool and method can be adapted to issues of urban development and management where it may be applied to all scales. This includes urban micro-business operations as well as the maintenance of large-scale urban infrastructures needed to fulfill conditions such as feasibility, value creation, and resource-effectiveness.

A possible complication of adapting a business model canvas, based on explicit rules, is that it may inhibit creative design decision-making. By outsourcing and decentralizing the decisions to a wider range of participants, such as a "Quarter Community", these rules might be supplemented by a consensus of implicit design ideas.

3.3.2 Urban Operations Model

The UOM helps to outline the otherwise hidden operational structures of cities which form the basis for their successful spatial and physical development. At the Wissens-Architektur Laboratory of Knowledge Architecture, we have sampled historical cases of prosperous cities, and demonstrated how UOM-descriptions can be applied as an analytic tool. We could show that vital cities usually possess a well-integrated urban operation system. Examples are plenty: Hellenistic Athens, the cities of the Hanseatic League, the transcontinental city corridor along the Silk Road, the creative city of Florence in the 15th century, or the city of Amsterdam as a center of trade of the 17th century. These cities were running on operational models that balanced partnerships, resources, markets, channels to accumulate and amplify knowledge and cultural production as well as wealth and political power.

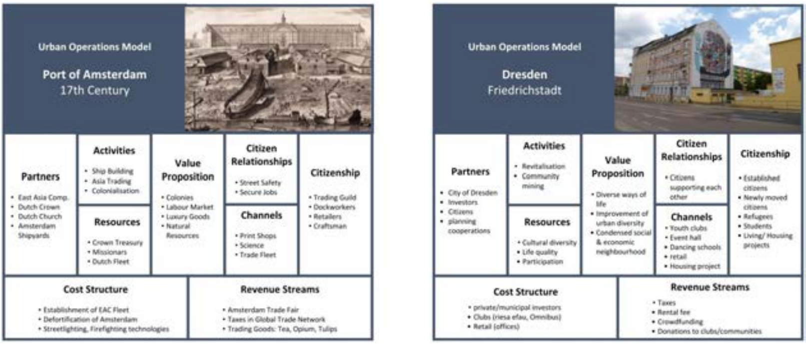

Figure 4 – Urban Operations Models for the Port of Amsterdam, 17th century (left) and for the contemporary Friedrichstadt residential quarter in Dresden (right).

However, these cities did not build their success on data and information technology which may be assumed a key resource and ingredient for UOMs in the 20th and 21st century. Arguably, no operational model and development scheme can be composed for cities, quarters, and buildings in the future without reference to digital data. The current capacity of data analytics, legal access to necessary data and the quality of available data may limit UOMs. We have extended the UOMs by processes of data acquisition and processing, and have shown how to integrate digital assets into the overall operations model of individual quarters or buildings.

The difference between urban and enterprise operations models lies in their different purpose as well as in the scale and application of the individual components. UOM consider socio-cultural benefits as prominent value propositions. Furthermore, certain original components need to be appropriated. “Customers” may be replaced with “Citizens”, indicating the urban context of the models.

3.3.3 Data Exploitation – Building ID and Quarter ID

The UOM, once established and comprising environmental as well as social datasets (City Data, Individual Data), needs to be analyzed and evaluated on a qualitative and quantitative basis. To do so, we introduced the “Building resp. Quarter ID” (BID / QID) (see Figure 5) as a visualization tool to describe this relationship. BID and QID are a kind of passport for the Internet of Buildings: they summarize all the indicators shown in Table

1 and rank their values. The aim of BID / QID is to valorize data linkages and create value for the various stakeholder groups such as citizens, planners, facility managers. The BID / QID thus functions either as an information display, aid, or a decision-making tool. Every new physical intervention, both temporary or permanent, alters the digital image of the BID / QID. While QID operates on a District-to-District basis, showing larger scale notions, BID operates on small-scale urban units, showing a larger data context[16].

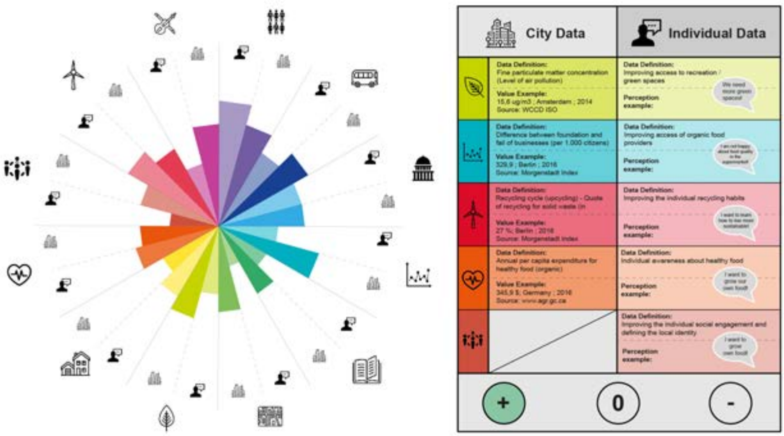

Figure 5 – Quarter ID (left), Building ID (right): Relationship between City and Individual Data at different urban scales.

3.3.4 Beyond Master Planning: Towards Data-driven, Agile Urban Development

Data collection in the urban Internet of Buildings plus the above-mentioned operations modeling may replace the practices of urban master planning with an agile and incremental development process. Somewhat paradoxically, data-based UOM may reenable the natural growth of cities and neighborhoods, eventually leading to high-value living environments.

Beyond master planning, we have schematized a process that builds ca pacity into urban quarters to structurally and flexibly react to changing

[16] As an example, Bert Spaan of the Waag Society created and organized a map (http://code.waag.org/buildings/) of all buildings in the Netherlands according to their age and described their brief function and size. This can be considered a basic Building ID.

needs and environmental conditions. The process – which actively utilizes ad hoc construction – can be described by a sequence of iterative phases.

The “Initiation Phase” starts with analyzing given datasets comprising City Data and setting up a Quarter Community for detailed insights into the needs of the inhabitants, summarized by Individual Data (see Table 1 above). The Quarter Community shall consist of at least one hundred participants who are periodically surveyed on quality of life in the quarter. This results in an initial Quarter ID (QID). By applying and downscaling the QID to a specific location or building, a Building ID (BID) is developed, and then a tentative UOM can be established.

In the “Seed Phase”, the process starts with a temporary pioneer or pilot construction in accordance with a first UOM. The site of development is equipped with Cyber-Physical-Systems for monitoring the initially defined usage. Prior to determining the nature of the pilot, qualitative and development-relevant urban data are collected (see Tables 1 and 2) through surveys or Soft Urbanism measurements (festivals, events, containers, light-material structures etc.). These data are collected and interpreted with the BID. Importantly, the Seed Phase does not necessarily imply concrete spatial or structural intervention. Moreover, there is a difference between greenfield developments and locations within existing urban blocks. Greenfield development may be more ambitious due to a lack of existing users, data streams and preestablished linkages to the surroundings.

By analyzing the BID, planners and analysts clarify whether positive impulses were given to the site, and thereupon decide further development scenarios. The seed intervention may either be continued, enhanced, or stopped. Following this feedback, planners outline an updated operations model which informs the next step of development, possibly leading to concrete structures. Thus, at the end of the Seed Phase a development brief is set up in the form of an Urban Operations Model, determining rules and orientation for the follow-up intervention. This UOM ensures, in any case, that the next step is socially and economically valuable, responding to the primary interests of citizens, developers and investors alike. During the subsequent steps of the development, the quarter develops more UOM as the demands, needs, and activities of users and citizens evolve and change. Past developments without sufficient response and attraction from the local community will not be followed further. As some activities will certainly fail, established and existing structures will need re-programming by other Seeds. Without a final masterplan, this iterative open-ended and potentially open source development continues, and importantly, is validated with every iteration. Thus, this agile process enables feasibility and calculability, and secondly, aids demand-matching and user acceptance. For developers and investors, this process offers an alternative to speculative ad hoc master plans: Financial risks become minimal through continuous validation (see Figure 6).

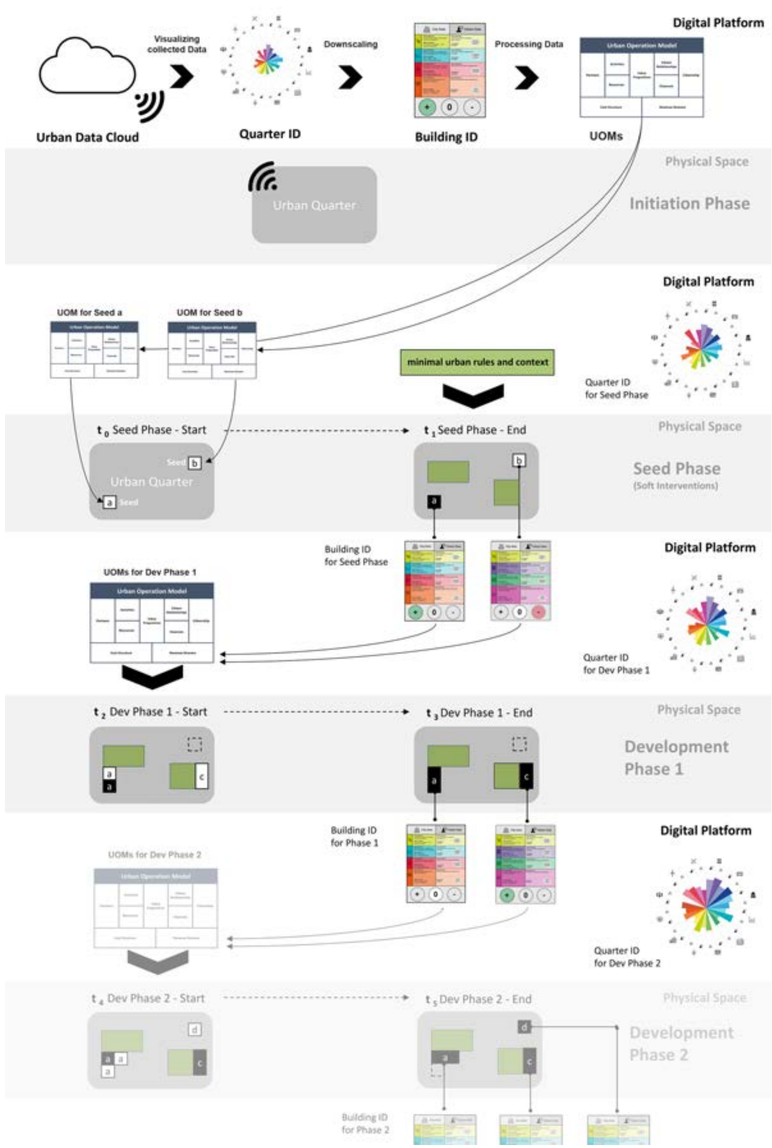

Figure 6 – Urban Data Operations Modelling: iterative steps.

The needs of cities for long-lived infrastructure networks can be addressed by iterative decentralization of embedded frameworks. Natural demand-driven city evolution beyond path dependencies at a large scale necessitates evolutionary and self-organizational processes that enable testing and experimenting at all levels.

3.3.5 Data Concierge and Urban Legislative

A key component for agile urban development is a data platform connecting different groups of interests in a network. These include municipal planning offices and municipal providers as the top-down actors, citizen organizations and entrepreneurs characterized as bottom-up participants and the investors, and developers and architects as hybrid figures (see Figure 7). On the one hand, the UOM is a formalization tool of ad hoc top-down urban planning rules. On the other hand, it supports a bottom-up dynamic catalyzing urban development, transmitted by processes and data visualizations. Appropriate data acquisition and evaluation is necessary to support design decisions and subsequent development. Today, both capitalist urban development and government-led master planning usually lead to undesirable urban conditions. A data platform, supported by UOM removes the discrepancies between experts and non-experts and may improve top-down master planning by harnessing data collection for progressive ends.

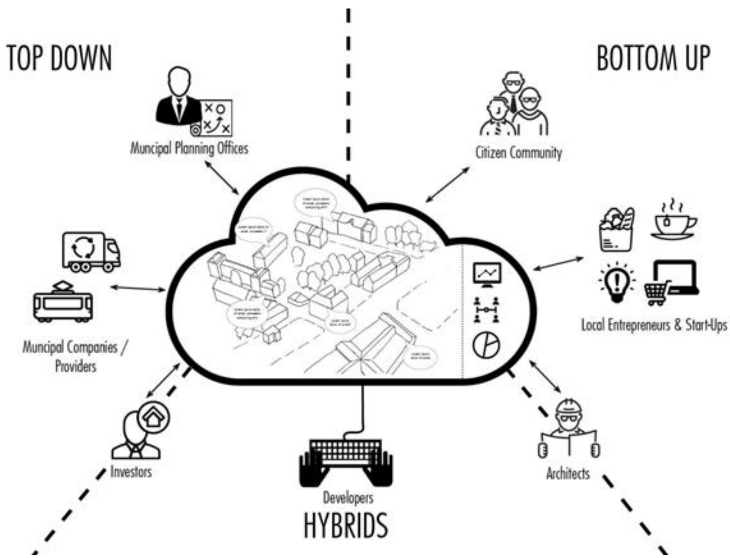

Figure 7 – Data4City: Data Platform and Stakeholders.

A first step beyond the conventional master planning paradigm towards evidence-based design is the re-definition of the roles and actions of individual participants. The linear workflow between investors, planners, municipalities and constructors needs to be replaced by iterative interaction and continuous evaluation of interventions as well as dialogue with end-users. Circular processes between the actors, as described in the previous sections, may eventually lead to an inclusive "Good City" with high quality of life.

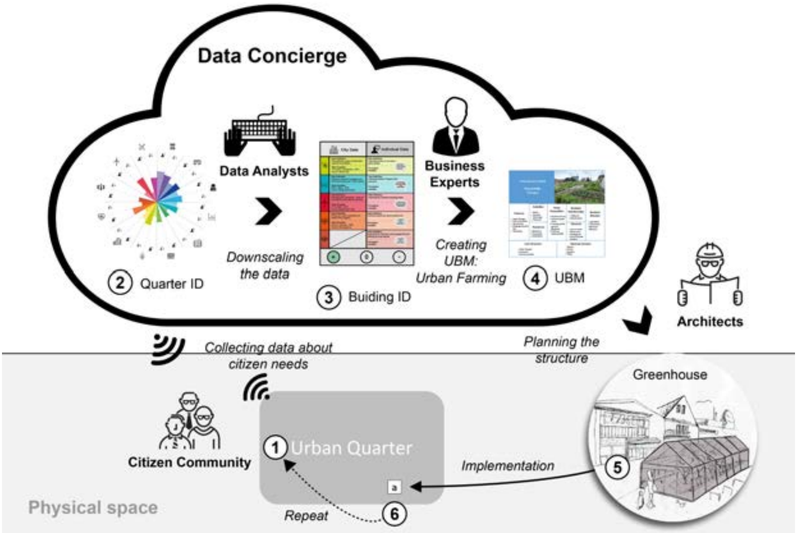

Figure 8 – Data Concierge: How data lead to design decisions (stakeholder map).

It is the task of an interdisciplinary team of data scientists, development experts and planners controlled by democratically elected citizen participants to take the role of a so-called Data Concierge who is responsible for managing, evaluating and processing locally generated data (Figure 8). An overall legal background can be established through an interdisciplinary team building the Data Concierge to guarantee its independency. Another important task is to guard against misuse of data. The Data Concierge can be furthermore seen as a hybrid authority (comprising both top-down and bottom-up decisions), making the legislative, background and general decisions according to the information derived from the datasets, democratic decision making.

A supplementary possibility for navigating and organizing the data concierge is an open-source peer-to-peer network with a flat hierarchy. Every interested inhabitant has access to most of the data flow and hence power to decide. The first method can be compared with the structure of a representative democracy, whereupon the second method resembles the structures of direct democracy. Both options have constraints and benefits. On the one hand, a method with representative elements is faster in decision-making, but power is not equitably distributed. On the other hand, a method with direct democratic constituents allows a nearly comprehensive rendering of inhabitants' needs and opinions, but impacts on performance.

4. Reflections – Limitations of Data-Driven Approaches to Urban Design

The limitations of smart city initiatives and data-informed design, as argued by Kitchin et al. (2015), lie in the generalization and over-simplification of diverse urban systems, disregarding regional and historical differences and rationalizing urban and social mechanisms. Arguably, the smart city agenda is driven primarily by corporate interests to capture financial and governmental opportunities (Hollands 2008; Kitchin et al. 2015). Furthermore, there are ethical consequences when people are categorized and reduced to mere numbers (Pentland 2014). This brings up the question of the general openness of any smart city system and how the data are being harvested. The distinction in the two methods for data collection (quantitative sensor-based vs. qualitative sociological approaches) in the proposed method may lead to over-simplifications of the terms "objective" and "subjective". Only the raw data collected by technical systems and sensors might be observed as fully objective and non-ideological, yet as soon as any filter is applied the objectivity disappears. Otherwise urban data cannot be seen as raw; they are always pre-defined for a specific use leading to a specific cause (Bowker 2005; Gitelman 2013; Kitchin et al. 2015). An approximation might be to define the filters through participatory decision making. This would eliminate more design contingencies resulting in a normative design model with less subjective and personal design decisions, which are in many cases driven by the ego of the architect.

Here, data types and resources were chosen that can directly inform design decisions, i.e. have implications for form, function and construction of urban structures. Only data resources, which are accessible and digestible for designers (who are typically not data scientists or statisticians), e.g., public data that are easily representable in diagrams and visualisations have been considered. These data sets are easily translatable to architectural or urban design decisions. Yet such a simplification of data, already observable in contemporary digital architecture, needs to go along with hierarchization and prioritization, leading again to subjectivity. By decentralizing these decisions through a network of interconnected users and stakeholders, objectivity might yet be achieved. Such a system based on peer-to-peer sharing might also be difficult to hack by a third party through blockchain technology[17]. Using blockchain, instant decentralized organisations can be developed, independent of any intermediaries or outside influences[18] (Ethereum 2017). This could also lead data-informed urbanism to a networked and possibly fully autonomous urban environment.

It is necessary to consider social conditions and issues of openness, especially in the context of data generation, collection, and economization. In this respect, hackability (modifiability) and open-source code must be considered central elements of the overall design in the light of technical democracy. The social impact of data-driven urban design and development requires bottom-up oversight (Farías and Blok 2016). Instead of giving away (personal) data to corporations and governments, the hyperlocal community presents a model to utilize and valorize data in the community and place where they are generated. In this model, urban space is being created by a constant iterative process of change and adaptation in response to the current demands and the actual needs of citizens. Latour and Yaneva (2008) described this idea as an active datascape informing the evolution of urban space, and modifying the social and physical context.

5. Conclusions

Max Weber (1921) considered that quality of life does not depend on the density or size of a city, but on its intermixture. This way, people of different ethnicities, cultural backgrounds and social classes can live together. Unfortunately, the appearance of radical functionalism and its zoning principles after the second world war rendered it impossible. Digitalization is a tool helping us move towards a healthy and appropriate dispersion of urban functions. Yet, there are principles which need to be respected in the context of data-driven cities, protecting the end-users who supply platforms with sensitive personal data.

Massive collection of Big Urban Data (individual data) can only be justified if a process is given for streaming essential data without the necessity of storing (Smart Urban Data).

Yet, in urban management and planning, urban data are not tapped as a major resource for design intelligence. In addition, cities are still not viewed as social enterprises which could be represented by way of operations models (Barquet et al. 2011). Addressing these deficits, Urban Operation Models (UOMs) provide for the purposeful application of urban

[17] A blockchain is an iteratively growing list of records (blocks), operating on a cryptographically secure, decentralized peer-to-peer network. Once recorded, the data in any block cannot be altered retrogressively without the alteration of all subsequent blocks. The first example of a blockchain is Bitcoin.

[18] See Ethereum Foundation: https://ethereum.org/ (retrieved October 5, 2017).

data, especially in the design and development of high quality living environments. Cities are places of value creation. This claim may be even more urgent in the digital age given that "wealth is created by turning data into information' (Landry 2000, 33). The case presented in this paper advocates the systematic usage of information and intelligence for valorizing urban design. The UOM provides a conceptual tool for urban managers, planners, administrators, and residents to capitalize on the rich urban data sources generated in the emerging Internet of Buildings (IoB). As a key component for data-driven urban design, this paper has shown how UOM can enable agile and secure urban development processes. Policy and decision makers can balance the interests of citizens with those of investors, developers, and managers through UOM. The primary aim is to get a more holistic and comprehensive understanding of the urban metabolism and hence give more power to citizens to design their own city and environment. The method moves beyond established practices in urban and forestalls real estate speculation driven primarily by expectations of return-on-investment. The power of the proposed method lies in the simple workflow procedure and the capacity to strategize and assess future development by way of operational modelling.

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DIO: A Surveillance Camera Mapping Game for Mobile Devices

Rafael de Almeida Evangelista
Cidade Universitária Zeferino Vaz Campinas (BR)

Tiago C. Soares
USP – Universidade de São Paulo (BR)

Sarah Costa Schmidt
Cidade Universitária Zeferino Vaz Campinas (BR)

Felipe Lavignatti
Cidade Universitária Zeferino Vaz Campinas (BR)

Abstract: Surveillance cameras are fast-growing technologies in contemporary society. In poorer countries, they are used to curb urban crime; in richer nations, they are also employed to fight terrorist threats. In this scenario DIO arises, a mobile phone game (still in development) that deals with the rampant increase of surveillance cameras in urban spaces. The game promotes a collaborative mapping of cities by inviting players to complete the following tasks: 1) geolocate, photograph, and log surveillance cameras scattered around the city; 2) compete against the opposing team for control of the cameras. Once registered, those cameras become playable geolocation points with which players can interact when physically close. This article presents the basic game plot, rules, and dynamics as well as a discussion on the increasing financialization and marketization of personal data and how to approach these issues through gaming.

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Corresponding author: Rafael de Almeida Evangelista, Labjor – Unicamp Rua Seis de Agosto, 50 - 3o piso, Cidade Universitária Zeferino Vaz Campinas – São Paulo, Brazil CEP 13083-873. Email: rae@unicamp.br

1. Introduction

Surveillance cameras are fast growing technologies in contemporary society. In Britain alone, one of the pioneering countries in installing public surveillance systems dependent on remote images, an estimated 5.9 million cameras are in use by public and private organizations (Barret 2013).

Security concerns are the main reason for the widespread use of surveillance cameras in cities – in poorer areas, to curb urban crime (Kanashiro 2008; Carr 2016); in richer areas, to fight terrorism threats (as illustrated by the large number of devices installed in Manhattan by the New York Police Department). In NY, there are 4,000 CCTV cameras, public and private, operating in a single part of the city. In Boston, a similar, albeit smaller system was employed to identify the perpetrators of the 2013 terrorist attacks (Kelly 2013). Writing on the use of CCTV in Barcelona, Clavell (2011, 525) states that it became popular as "part of a broader project to promote 'civility' and eliminate 'anti-social behaviour'". Working properly or not, CCTV has become part of our cultural repertoire (Groombridge 2002).

Surveillance cameras are one of many technologies – like traffic sensors, pollution monitors, flood sensors and others – that are becoming part of the infrastructure of "smart cities". These initiatives use data-collection and analytics in support of city planning, infrastructure maintenance, preemptive policing, and management of urban flows and mobilities. Leszczynski (2016) cites centralized command-and-control facilities (that heavily depend on CCTV to function) as one of the examples of real-time urban big data for managing the here-and-now. Besides that, those data-driven contemporary technologies work as a safeguard against social and natural disasters, "subscribing the horizon of possibilities to exclude potential scenarios deemed undesirable or deleterious" (Leszczynski 2016, 1692).

Concerns over vigilantism and the real effectiveness of CCTVs in fighting violence make their use somewhat controversial. In many democratic nations, civil rights organizations have criticized the proliferation of surveillance systems, claiming privacy rights violations. The ACLU (American Civil Liberties Union), for example, argues that cameras 1) would be susceptible to abuse; 2) are not proven to be effective; 3) would not be properly controlled; and 4) would have a chilling effect on public life (ACLU).

In Latin America, the legal frameworks concerning surveillance are fragile and lack specific regulation (Firmino et al. 2013). In countries like Brazil, home to global events like the 2014 FIFA World Cup and the 2016 Olympics, the government, in an effort to prevent terrorism, has expanded the reach of surveillance operations. Kitchin (2014) understands that effort as related to the current practice of governments using real-time analytics to manage aspects of how a city functions and is regulated. He mentions the Centro de Operações da Prefeitura do Rio (COR) as an example of an attempt to draw all kinds of surveillance and analytics into a single hub:

> (...) the Centro De Operacoes Prefeitura Do Rio in Rio de Janeiro, Brazil, a partnership between the city government and IBM, have created a citywide instrumented system that draws together data streams from thirty agencies, including

traffic and public transport, municipal and utility services, emergency services, weather feeds, and information sent in by employees and the public via phone, internet and radio, into a single data analytics centre (...). Here, algorithms and a team of analysts process, visualize, analyze and monitor a vast amount of live service data, alongside data aggregated over time and huge volumes of administration data that are released on a more periodic basis, often mashing the datasets together to investigate particular aspects of city life and change over time, and to build predictive models (...). This is complemented by a virtual operations platform that enables city officials to log-in from the field to access real-time information. (Kitchin 2014, 6)

Sadowski and Pasquale (2015) cite COR as the best example of a *smart shock*, "wherein a city undergoes a quick, large-scale integration of 'smart' ideals, technologies, and policies into an existing landscape". According to them, the city of Rio was turned into a system for optimization and securitization, with the amplification of already existing practices of militaristic urban control.

An article from the technology magazine "Motherboard" (Kayyali 2016) reports that the process started just before the 2014 World Cup, spawning "drones, facial recognition goggles that can scan 400 faces a second and check them against a database of up to 13 million images, and 122 surveillance helicopters, many outfitted with HD surveillance and infrared cameras". This technology has also been used to stifle political protests, like the demonstrations that questioned the extent of investment in the 2014 World Cup and in the 2016 Olympics in Rio de Janeiro. An extensive news report from the news agency "Pública" shows how the surveillance equipment bought for those major international events was expected to be used both against possible terror acts and for fighting urban violence, and how political protests were treated as a major threat to the security of tourists and athletes (Viana et al. 2017).

However, most cameras spread throughout Brazil perform ordinary functions – they are not solely in the hands of the state for crime prevention, gathering evidence, or legal proceedings. Normally, violence prevention is jumbled in with practices of segregation and social cleansing (Kanashiro 2008). Cheaper technology and the popularization of surveillance equipment have made it nearly impossible to commute in urban areas without being filmed. New digital image processing technologies enable widespread identification procedures, and its uncontrolled use interfere with the management of public areas: police departments are increasingly engaging in preemptive operations, leading to abuse, racial profiling, and gentrification[1].

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[1] Vlahos (2012) inform us about the use of "data-rich computer technology" being used by several police stations across the US to predict crimes. Jouvenal (2016) reports on Real Time Crime Centers functioning in US cities like Fresno and Seattle, in which individuals can be scored based on their threat level. After helping the Seattle Police Department to launch its Real Time Crime Center, the

Cameras are being used to watch employees and customers in shopping malls, bars, and stores for a number of reasons. In public spaces, they also monitor areas such as streets and sidewalks, mapping – and, in some cases, preventing – the circulation of determined groups. In both cases, these groups cannot do anything to prevent their identification and monitoring. And public squares, where pedestrians are of particular interest to the real estate business, are monitored to exclude 'undesirable' groups (Kanashiro 2008; Kanashiro 2006). Put together, such space monitoring hardware and software lead to an *automatic* production of space (Thrift and French 2002), with relevant social consequences. As something written by humans, software (and hardware) challenges us to comprehend these new forms of technopolitics and practices of political invention: "politics of standards, classifications, metrics, and readings" (Thrift and French 2002, 331). The software and hardware designed to perform functions on space also inherit the bias, preferences and opinions of those who made them. Leszczynski (2016) also points in that direction when she states that as the city is subsumed within the data-security assemblage, algorithmic governmentality follows the urban realities of inequalities.

As said before, cameras targeting public areas such as squares, streets, and sidewalks, are used mostly for two purposes: to control urban violence and crime; and to manage traffic. In both cases, the installation and control of surveillance equipment is usually provided by private or public bodies; but there is a caveat – when it comes to the institutional management of surveillance systems, government authorities may also share the control with private, outsourced agencies (Cardoso 2012)[2]. In some situations, these roles and functions may be intertwined, such as when traffic control cameras record a significant event "by accident".

Gated communities, a housing modality that has grown tremendously in Brazil (currently accounting for nearly 2% of all households; Uchinaka 2011), boast security as one of its major desirable features – a promise epitomized by the large number of monitoring cameras usually found in them. In developing countries, the fear of urban violence is one of the main reasons for the growth of this type of housing, and some form of complementary "technical fix" (Firmino et al. 2013) is frequently installed to further secure the physical enclosure of the area. In common areas, such as elevators, lobbies, and leisure areas, cameras may give rise to abusive actions suffered by residents as well as employees.

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private company Via Science was involved in the development of the predictive features of CrimeRadar, a publicly available crime-forecasting tool based on open-access that was launched in Rio de Janeiro after the Olympic Games of 2016 (Capps 2016).

[2] Cardoso (2012) tells us about the involvement of at least three different companies besides the State Department of Police in the management of Rio de Janeiro's Command and Control Center (CCC).

Images are now easily stored and maintained for indefinite periods of time in databases. They can be sent to be examined in remote places and easily copied and multiplied. They can also be analyzed by software capable of identifying characteristics invisible to the human eye. Graham and Wood (2003) point the social effects of digitized surveillance, stressing that the current social conditions are the privatization of public spaces and services, coupled with a notion of citizenship linked to consumerism. The authors note that "digital surveillance also provides a new range of management techniques to address the widening fear of crime and the entrenchment of entrepreneurial efforts to make (certain parts of) towns and city spaces more competitive in attracting investors and (selected) consumers" (Graham and Wood 2003, 234-235).

There is evidence that the same measures meant to promote human security can, potentially, also foster feelings of insecurity, vulnerability, and exposition (Esposti and Santiago-Gomez 2015). Surveillance technology companies advertise the economic benefits of the use of their equipment in workplace environments. For example, one company claims that "business managers can study customers' shopping habits by studying videos recorded by surveillance systems.[3]"

2. Visualizing Surveillance

The tension between power, security, and freedom echoed in the cybercultural debate is longstanding. In the 1960s, in opposition to the institutions of technocratic control and censorship of the Cold War, social movements manifested deep concerns for freedom of expression and individual autonomy. In the United States, these movements would go on to stimulate communities that promoted social, artistic, and technological experiments, culminating in the microcomputer revolution and new cultural arrangements (Turner 2006). Influenced by the Free Speech Movement at the University of California, Berkeley in the 1960s, on through to the hobbyist computer clubs and experimental, autonomous communities scattered throughout California in the 1970 and 80s, Silicon Valley emerged as the epicenter of what would become a new, hegemonic knowledge management model. Through the idea of technological appropriation, the Cold War mainframe was reinvented into the microcomputer – and, as so, became part of a new, individual, cognitive apparatus. From desktops to laptops, and finally to smartphones and the internet of things, the computer became a device of higher technology, uniquely integrated to each individual user.

Castells (1996) claims that the prominence of the Californian techno-

[3] See https://reolink.com/why-does-your-business-need-video-surveillance (retrieved June 28, 2016)

scientific complex is embedded in a wider, international economic transformation. The delocalization of factories and production, and the emergence of financialization as the core of the western economy, created the need of an ever-stronger, ever-increasing machinery for the widespread data-management demanded by a global connected economy. Critics like Winner (1997), Barbrook and Cameron (1996), and Morozov (2014) expand on the worldview summarized by Castells, and counter the notion of a supposed neutrality on the role played by technology – especially when it comes to political economy and structural changes. These authors will articulate a critique of Silicon Valley, viewing in its latent technodeterminism an essentially ideological project – the *Californian Ideology*.

This movement, with its nod to the experimental propositions of technologists influenced by radical theorists such as Jacques Ellul (1964), Herbert Marcuse (2013[1964]), and Ivan Illich (1973), draws, however, on a powerful internal antagonism. While increasingly sophisticated individual control of technological devices offers possibilities for invention and disruption of asymmetric power structures, the colossal volume of data generated by these same devices unearths new monitoring and controlling tools. In the realm of the State or in independent groups, networking tools such as IMSI catchers (low-cost interceptors used in cellular networks), mesh networks, and hardware/software toolkits for remote monitoring create a scenario that not only increases government control but also sets in motion actions of dispute and resistance by a number of civil society groups, promoting a game of perpetual power and counterpower.

Bruno (2014) reminds us of the overlap between surveillance culture (video surveillance and social networks on the Internet) and the "society of the spectacle", with links to surveillance, blatantness, and pleasure. Surveillance cameras mimic the image (sometimes sound) capturing technologies which are the base of the most popular entertainment products of the twentieth and the twenty-first century. To observe using them, and to be observed by tkhem, involves a certain discipline of body and attitude, and are also practices associated with entertainment and expression.

The same thing that can be said about the relation between play and management can be said about games and surveillance. Koskela and Mäkinen (2016) state that surveillance and games are intertwined and that "examining the game elements of surveillance facilitates a broader understanding of how this practice moves beyond power and discipline". They also try to use the idea of game as a tool to dissect surveillance, offering five different metaphors. In one of them, they argue that surveillance can also be understood as a labyrinth, saying people can playfully navigate through surveillance spaces, sometimes trying to avoid being monitored.

In the relationship between the one who watches and the one who is being watched, issues such as the visibility or invisibility of surveillance devices should be discussed. While people and their actions are disciplined by the presence of surveillance cameras, the lack of public debate on their use only promotes the unregulated proliferation of the technology, increasing the cases of abuse. To study and map cameras can be an effort of resistance to its power. In a city that becomes aware of itself, "sentient" (because it is loaded up with information and communications technology), Thrift (2014) says that new technical-artistic interventions are required if we are not to become simply servants of the security–entertainment complex. Brighenti (2009) comments on the interplay between artists questioning the surveillance society and the ideoscape of surveillance forming a collective imagery about what security, insecurity, and control are about. He also points out that different kinds of recent art works can be interpreted as an attempt to deal with visibility regimes shaped by specific asymmetries.

Bruno (2014) points out that the "beginning of the dissociation of the see-and-be-seen principle, associated with the principle of 'unverifiableness' of power," is crucial to the fulfillment of one of the purposes of the panoptic machine described by Foucault – the automatic functioning of power:

> If you can discern the eye spying on me, then I dominate the surveillance, and I spy on it also, learning its intermittence and faults, and I can study its regularities and rid myself of it. If the eye is hidden, it looks at me, even when it's not seeing me. (Miller 2000, 78 quoted in Bruno 2014, 60)

The question arises: given the widespread use of video surveillance technology in contemporary society, and the broad, global use of portable devices for personal network-computing, what can we develop to physically expose many of these surveillance apparatus and information processing equipment in order to recognize, as best as possible, not only their existence but also their potential? On the other hand, what can we do to denaturalize their presence in urban settings in order to create a discussion on how to socially discipline them? Currently, it is impossible to dissociate digital networks from these devices. Digital images and sounds roam the networks, forming the raw material of entertainment and media products. Algorithms analyze the digitized content to recognize patterns, which are then cross-referenced with other databases.

Our proposal is a mobile app[4] that we are calling DIO: a playable, collaborative platform for the mapping of surveillance cameras through augmented reality and the geomapping of urban areas. The game is designed to be played daily, so that the flow of players (carrying their mobile devices) in monitored areas could be continuously processed and

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[4] The app is in development stage and has financial backing from the Ford Foundation as part of a larger project named "Rede Latino–Americana de Estudos sobre Vigilância, Tecnologia e Sociedade (Lavits): interseções entre pesquisa, ação e tecnologia", which is developed by Lavits (www.lavits.org).

turned into playable data. We intend by this to expose and discuss the presence and use of cameras, emphasizing the centrality of urban flows in the functioning of surveillance systems.

In his review of many art or intervention projects dealing with surveillance, Brighenti (2009) cites iSee (2001-2005), a now defunct web-based application that maps the locations of surveillance cameras in urban environments. Our effort is similar, but to achieve a comparable goal we use playful elements, focusing on the dissemination of mobile phones. Studying location-based social networks as Foursquare, Saker and Evans (2016) coin the term "playeur" to try to describe an engaged actor that develops relationships with space and place through intentional playful activities. To achieve that the playeur, like the "phoneur" (Luke 2006), uses his or her smartphone to change how the urban space is traversed. In this sense, DIO is a mobile game that relies on the player experience to engage in a critical relationship with regimes of visibility.

In the development process, we opted for narrative elements and gameplay structures aligned with that of other games that make intensive use of surveillance tools and personal data processing – games like Pokemon Go (2016), Watch Dogs (2014) and Ingress (2012). The purpose is twofold: on the one hand, we may offer structures with which players are already familiar; on the other hand, we will be able to engage in a critical appropriation of these schemes not for surveillance[5] but for discussion – although as O'Donnell (2014) says, the use of surveillance in one form or another is inevitable. Ingress (2012), which is also a game that relies on the mobility of the players, is particularly a case we want to address. Using gamification mechanisms, the game nudges its players to catalog historical buildings, street art and tourist landmarks. At the same time that it promotes "datafication of one's mobile life in exchange for the gift of play" (Hulsey and Reeves 2014), it is one of the best examples of the connection between gamification and big data and algorithmic surveillance. DIO uses a very similar game dynamic to put the surveillance at the core of the game plot.

Following Thrift and French (2002) on the discussion of the "automatic production of space", Graham and Wood (2003) recall the opacity and ubiquity of these computer systems and their process as a whole, as it becomes difficult to identify how the shift to automatic, digital and algorithmic surveillance is linked to profound changes in the political economy of urban space management. By giving prominence to these systems of imagery and informational surveillance, we want to contribute towards bringing them to the fore.

More than just plotting an accurate map of the cameras, pointing out exactly how many and of which type they are, we propose that these devices are turned into elements of an online environment in which players can interact, while also revealing that these devices actually exist and have

[5] No data regarding the player's identity will be stored or commercially used.

effects beyond the locations where they are found. We also suggest renewed discussions on technological re-appropriation: in the twentieth century, criticism of bureaucratic control by the military-industrial technocracy brought up new technologies and their use in the reshaping of power structures. Today, in the interconnectivity between the digital environment of the game and the real world, we want to discuss surveillance cameras and put them into focus.

To articulate the proposed debate, we offer – as an element to guide player actions – a background story that contextualizes aspects of the use and production of technology in contemporary society, such as the surveillance society (Lyon 2001), technology ownership, and political and economic uses of personal data.

Van Brakel (2013) suggests the need for a more generous understanding of what "play with surveillance" means. Playing with surveillance, she says, "can have a transformative effect both on the person playing but also on social and cultural norms". But she also alerts us to the possible normalizing effects it could have on how people perceive and give meaning to surveillance. Although we are using surveillance as a theme for the game and suggesting its daily use, our goal is to produce the exact opposite to a normalizing effect. The objective is to create awareness of the surveilling processes, in an effort to stimulate democratic questioning. Thrift and French (2002), when discussing the automatic production of space, suggest that, in the house of the near future, the operating system of the computer that runs the house would be as important as the roof. The cameras that today surveil the major cities of the world are one of its most important sensors. We want to incorporate the surveillance apparatus of the cities as an element of the game. Hulsey and Reeves (2014) and Stenros et al. (2011) tell us that many augmented reality games (ARGs) often incorporate non-players into the gaming experience. The game DIO is an effort to produce ludic awareness about the location and the interconnectivity of the informational and surveillance systems that currently pervade our everyday lives.

3. Storytelling and Development

Based on the worldwide use of smartphone geolocation tools, the game proposes primarily what could be understood as a new "layer" of use. The geocoding platform developed for the game is based on solutions commonly applied in other tools found in mobile devices, so that the players' actions, when it comes to input, classification, navigation, and database processing, are, strictly speaking, similar to the usability found in apps for restaurants, relationships, or taxis. It is a narrative that encourages not only the discussion of surveillance in public areas, but also the uses and possibilities of technological tools whose presence has become "natural" in daily life. It is interesting to remember that the transnational surveillance structures uncovered by Edward Snowden (Greenwald 2014) in the early 21st century are based, in no small part, on the monitoring of personal devices such as laptops and smartphones.

The development of the narrative, as well as the technical and functional structures of the game, underwent a series of conceptual workshops involving the project's team. Apart from attending communications symposiums, the project team had conversations with technical experts and specialists in technology and policy, as well as inquiries into the state of the art in digital and experimental games conducted by research groups in Brazil[6]. From a Brazilian (and, probably, South American) standpoint, a main challenge in video game research seems to be the development of permanent, sustainable projects and interdisciplinary teams. The convergence of different academic expertise and faculties into development projects is in many cases a result of specific, individual interests, rather than institutional frameworks. Funding and programs devoted to research on digital games are still somewhat rare, despite a growing interest among the academic community. Even though a considerable part of the existing research and development may seem incipient and/or rather inconsistent, there appears to be an ongoing increase in the quality of the projects, both in their methods as well as in their results. Mapping (and mastering) these pitfalls has probably been one of the main tests faced by our team.

To transition from a concept to a playable platform, the development team researched the narratives and gameplay featured in games of all types and generations, as well as aesthetic references in documentation and products associated with videogames and their role in popular culture. There were also studies on thematic and dynamic narratives in film and science fiction literature. Collected data was organized into conceptual streams for eventual implementation into the game development by the project's tech team.

The term "cyberpunk" was officially adopted in the workshops. The decision to use the term has historical context as well: cyberpunks are the heirs of the cultural propositions of the 1960s and 1970s that culminated in the reinvention of the computer as a counter-hegemonic, organizational tool. Movements that, in their critical discussion of politics and technology, engaged in lengthy experiments with science fiction as an outlet for not only literary speculation, but also as a platform for political, technical and organizational experimentation. As Lee Felsenstein (2013) explains in his memories, the countercultural experimentation that led to the "hobbyist culture" and the "garage microcomputer" was heavily influenced by the ideas, groups and networks built around the science fic-

[6] See the *Congresso Brasileiro de Informática na Educação e Conferência Latino-Americana de Objetos e Tecnologias de Aprendizagem* (2015) http://www.br-ie.org/pub/index.php/teste/issue/view/135 (retrieved March 30, 2016).

tion scene[7] of the 60s and 70s (Rossman 1972).

The visual patterns that were created for DIO resemble the science fiction of the late 1970s and 1980s. You can find below a screenshot of one of the first screens of the game, right after a player logs in. The game is a web-based application, so it works both on desktop computers and mobile phones. The following screen was taken from a desktop computer browser. You can see a button on the left of the screen to add a new mapped camera, and a small window with some player information.

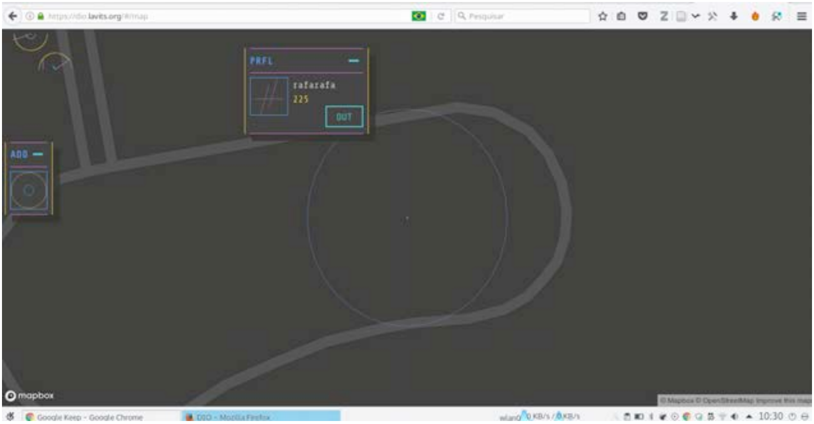

Figure 1 – Screenshot of the game from a desktop computer. The small blue dot represents the player's location. The blue line is the player's area of action.

4. Argument and Dynamics

The game seeks to trigger traditional role-playing gaming, unhinged and mediated by users and their collaborative groups. The development of the narrative and personal story of each player in the game plot is performed by managing the georeferencing platform and its data, without the use of guided navigational elements or 'closed off, on rails' playing levels. It is a Massively Multiplayer Online Game (MMOG) and also a pervasive game (also known as hybrid games, location-based games, and mobile games). Stenros et al. (2011) note that pervasive games are not played necessarily on computer screens (although they might use them)

[7] Ballard (1962), in the final decades of the twentieth century, summed up what came to be the New Wave of Science Fiction and its interface between counterculture and sci-fi: "The biggest developments of the immediate future will take place, not on the Moon or Mars, but on Earth, and it is inner space, not outer, that needs to be explored. The only truly alien planet is Earth".

or in predefined spaces or set times. Kerr et al. (2014) identified five elements that are part of the system of governance in MMOG (game code and rules; game policies; company community management practices; player participatory practices; and paratexts). They conceptualize these governance elements functioning as a "surveillant assemblage" (Haggerty and Ericson 2000). The assemblage Kerr et al. (2014, 333) typify and analyze "demonstrate that game governance by companies responds to, and shapes the behaviour of players but is often in flux, shifting and adjusting". One major challenge for the governance of DIO is to promote this flux according with the game goals.

At this phase of DIO's development we are focusing on the definition of the game's code and rules, as well as on its paratexts. The basic rules and game dynamics are mostly defined, although it should be modified according to feedback from gamers. Paratexts will be an important element to address the main social issues the game intends to thematize: the widespread deployment of surveillance cameras in urban areas; the growing digital management of urban spaces; and the economic use of personal data. Game policies should emphasize that DIO 1) is not a commercial project; 2) respects the privacy of its users by collecting only data essential for the game's proper functioning; and 3) is a free and open source project. The game should be freely available for iOS, Android and Windows phones, as it has been developed as a Progressive Web App (PWA). PWAs are regular web pages that can appear to the user like traditional applications, trying to combine features offered by browsers with the benefits of mobile experience.

Other elements should be dealt with before an alpha version is available. DIO is a game about a surveillant assemblage – the interconnection of CCTV, speed radars, computers, mobile phones etc. – which as an MMOG will require the use of other surveillant assemblages for its governance.

The proposed scenario is the 'very near future' – a reality in which artificial intelligence is used by governments as a tool for social control. To develop the story, we studied with special attention popular games such as Watchdogs, in which a supercomputer (a ctOS - Central Operating System) that connects everyone and everything – personal information, traffic lights, mobile phones, and security cameras – is implemented in Chicago, Illinois, after a hacker attack.

In our plot, governments and companies, to combat opposition, employ surveillance technologies that scan physical spaces and monitor digital networks. To improve this system, a multinational public-private partnership project is launched to create a technological standard. This protocol, developed with the objective of integrating public surveillance devices around the planet, is called Digital Information Operative (DIO). It is an effort to create an intelligent technical protocol that integrates cameras and forms a system in which all units are accessible remotely. Quietly test-launched, the project receives the collaboration of many companies and technicians, who vindicate for globalized efforts for transparency and scorn upon alerts and claims of human rights violations. Shortly thereafter, the initiative is terminated, also quietly, and the project never officially goes into operation.

It would, however, all prove to be a farce. Once testing starts, the artificial intelligence that would integrate devices around the world becomes uncontrollable. With all cameras consolidated, it becomes impossible to cut them off from the network for a long period of time, being that DIO reestablishes lost connections. The project was discontinued and the autonomous existence of DIO was never publicly admitted for fear of negative backlash. And now, as a result, every camera in the world is subject to the control of DIO.

Every footage and image provided by the cameras is now online, available in a 'deep web' of sorts, and is accessed by political, economic, and technological operational groups. It is impossible to turn them off effectively. Governments and corporations can finally watch over and track everything. It is the end of privacy. DIO now fully displays and broadcasts society's weaker bodies, while members of power remain concealed and blanketed. Footage revealed in the network continues to be wielded by governments. After an effective disinformation campaign, the mere existence of DIO is seen as just a rumor, a ghost story.

For the overall public, DIO is just a conspiracy theory. However, for resistance groups, it is reality. Naturally, the resistance split into two distinct groups, with two different philosophies. The Blind group believes that the best action to take is to blind all cameras, because image capturing technology in itself is detrimental. The Lens group believes that the best way is to restore autonomy to the cameras, as well as to their original owners – if the devices are finally dissociated from DIO, their original owners (the companies) would make good use of them. Both groups apply these different outlooks not to fight against each other, but to battle DIO. Nevertheless, DIO ends up regenerating itself and reactivating and reincorporating the cameras to its network. The groups continue their fight in search of a permanent solution.

The game dynamics are inspired by controversial commercial games like Ingress and Pokemon Go. Hulsey and Reeves (2014) highlight that Ingress is an emerging form of digital economic exchange, which requires the datafication of the player's mobility and communicative actions. In exchange, the game offers privilege of access to its platform. At the same time, the authors note the standardization of surveillance and data mining contained in games such as Ingress. Unlike these commercial applications, we intend to use data mining not as a commercial viability item of our platform, but as a thematic element of the game. The same is true for camera surveillance and the integration of imaging data, which are exploited by their exposure and estrangement, not by their normalization.

Players and groups interact with the game and its proposed background story by inputting data 'inside the game' (among profiles of registered players) and 'outside the game' (among players and cameras soon to be mapped and inserted as playable elements). Mobile devices, from which the game are run, are also adapted and redimensioned. In the game plot, the DIO app is presented as a fictional hack, offering players a new way to control their smartphones. By 'shielding' DIO surveillance protocols and giving smartphone owners the power to act and resist in the global technology grid, smartphones become, in the DIO universe, technological re-appropriation devices and a political statement.

For players of both resistance groups, actions comprise a) registering and geolocating surveillance cameras scattered in public areas; b) fighting for 'ownership' of each of the logged cameras. To register and geolocate the camera, the player must approach the device with their mobile phone GPS activated and snap a picture, and, optionally, log in information as to where the camera is pointed (to a public or private area, for example) and its model.

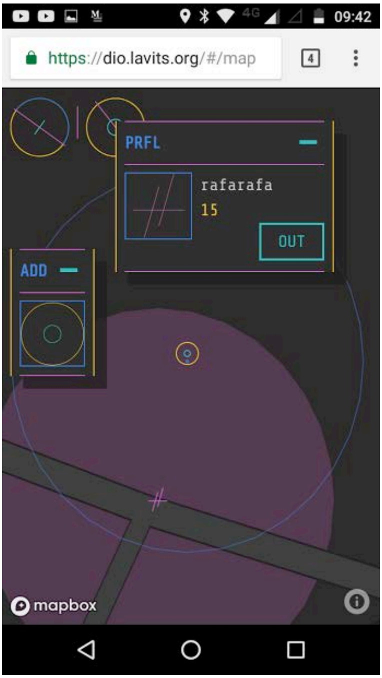

Figure 2 – Two cameras mapped by users.

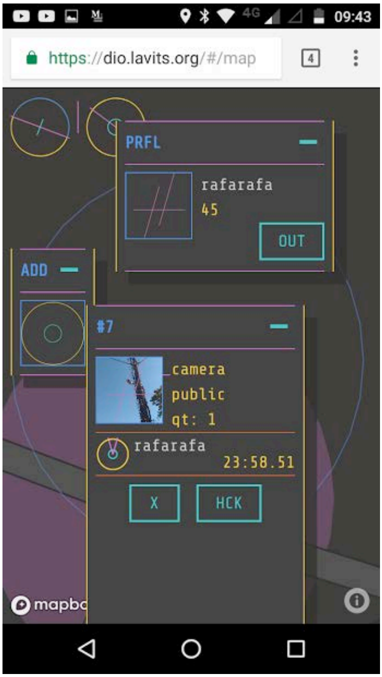

Figure 3 – Picture of mapped camera inserted by user.

To compete for the possession of the cameras, the player must have his/her GPS function activated and be within a radius of 50 meters of the geolocated object, and then interact with it. Each interaction, which may be performed in predefined time intervals, increases your radius of control over the camera. For example, if the camera is under the control of the Lens group and a player from the Blind group goes through this area, Lens will lose points, and vice-versa.

The interaction, or the hacking of a camera by a team cancels the opposing team's interaction. Cameras/objects have a pre-set maximum radius perimeter that allows for interaction.

Game functions are still in development, and new implementations, adjustments, and tools are being studied.

The next two screenshots were taken using a mobile phone. Fig. 2 shows two mapped cameras: the closer to the street was hacked by a player and is in possession of his team. Fig. 3 shows a picture of the hacked camera, the time lapsed since the last hack and some information about the camera (a picture, the number of cameras, and if it is a directed towards a public or private area). Both also show some information about the player: his or her username, the number of points at that moment. The symbol right next to the user name shows that the player belongs to the Blind group.

5. Commercial Use of Personal Data

DIO is a MMOG. Each player has a username and accumulates points. Points permit the acquisition of new playable items that increase player potential, contributing to the wellbeing of the group.

When analyzing MMOGs, Kerr at al. (2014, 321) remember that "the client-server architecture generates huge amounts of data flows and rich databases of player and game behaviour. Game companies use this data to survey player activities, tweak the game design, and monetise the game". Our goal is to expose this kind of data collection, allowing for players explore their own data. For example, each user would be allowed to view the paths they took, on which days and times, and with which cameras they interacted. We must consider that this information may also be stored by other apps.

This functionality allows us to address the commercial use of personal data gathered through surveillance. In the same way we took into consideration the visibility of video surveillance devices in the game's context, we also intend to reveal how data gathering techniques are central to the operation of the game.

Commercial use of personal data on the Internet is constituted, just as surveillance cameras, as a controversial social issue that has been the subject of legislative proposals. It involves citizens (Internet service users); companies providing these services (that use data as raw material for intelligence analysis with commercial purposes); and governments (which use collected data to provide public services, political repression, and security practices).

It is estimated that by 2020, the market for 'digital identities' in Europe will sum up annual profits of up to 1 trillion euros (Boston Consulting Group 2012). Companies have made significant efforts to distance themselves from negative perceptions linked to governments and political surveillance. They intend to position themselves as having less power over citizens than our governments. They argue that, given freedom of competition, citizens are free to choose alternative services and that legislation's only function is to curb misuse and any eventual personal data leaks (Ashton-Hart 2014).

It can be argued, however, that migrating to other social network services is not that simple. "It's difficult for you to leave if all of your friends are members of a particular service, even if you don't agree with privacy settings changes," states Peter Schaar, Chairman of the European Academy for Freedom of Information and Data Protection (Schaar 2014). Another issue to consider are the astronomical profits projected by the information industry. Control and storage of personal data, which has been called the 'new petroleum', is a significant economic force that affects the global economy and, consequently, social relations. More than ever, information is power, as discussed by Ceglowski (2016):

> In our attempt to feed the world to software, techies have built the greatest surveillance apparatus the world has ever seen. Unlike earlier efforts, this one is fully mechanized and in a large sense autonomous. Its power is latent, lying in the vast amounts of permanently stored personal data about entire populations.
>
> We started out collecting this information by accident, as part of our project to automate everything, but soon realized that it had economic value. We could use it to make the process self-funding. And so mechanized surveillance has become the economic basis of the modern tech industry.

It is a difficult task to discuss and convince the public that their personal data has commercial value. Zuboff (2015) describes broadly the phenomenon and its logic of accumulation, calling it "surveillance capitalism". From the individual's perspective, data seems to be very trivial information. True concern only emerges with regards to sensitive data, such as bank account information, which can be stolen by criminals with the intent of illegally transferring funds (Firmino et al. 2011). Through its gameplay, DIO demonstrates what data can actually reveal about individuals, even if anonymously. More importantly, the game can show how personal data has become a tradable good. Accumulated data from other users means exponential profit growth. On the other hand, providing this information to others means losing power.

In a later stage of app development, new features that relate to this aspect may be implemented. One possibility is to create a system in which players exchange sets of information for game points (anonymously added according to playing time). The market for such exchanges wouldn't be 'official', but game administrators would minimally regulate the nature of the exchanges.

Reward points would follow a nonlinear, exponential progression, thus emphasizing the value of being in possession of such vast databases. Similarly, gameplay for users with few points could be difficult, thus signaling that those who have amassed more information and more points have greater power and convenience.

These new features would be developed based on the actual characteristics of the personal data market. Therefore, by using the narrative features of the game, we would create a tool to discuss privacy and personal data.

6. Conclusions

There are several elements developed for the game that relate to current issues involving privacy, security, and power, such as the uncontrolled dissemination not only of cameras but of sensors capable of capturing information, as well as the indiscriminate data exchange between state agencies and private corporations. Even the differences established between the game's resistance groups – those that advocate for social control over technology, and those calling for radical disruption – echoes those of contemporary ideological currents.

The game story is still open. New elements may be added, along with new playable tools. Mobile phones have become powerful sensors that produce and transmit data continuously. This data is commercially used by technology companies (Evangelista 2016). We also intend to develop elements and playable items that portray this fact.

This project, in its complexity, from the development of the backstory and the coding of the game to the analysis of how the players are using the game, can be classified as a kind of sociological experiment. We are a group of independent academic researchers in the periphery of the info-industrial world. Using trends of the current game industry that emphasize different modes of surveillance seen in commercial games like Ingress (Hulsey and Reeves 2014, 389) and Pokemon Go, can we produce a game that challenges the surveillance culture? Canossa (2014) tells us about the growing trend among players towards unconditional acceptance of behavior tracking in digital games, and discusses the balance between the monetization of data generated by use and its compensation in different forms. How can we thematize surveillance capitalism (Zuboff 2015) and how will the players respond to that?

The game should be promoted initially in Latin America, in countries where there is a history of violation of human rights and where the institutions created to protect civil rights are recent and fragile. How will media, government and the public react to our effort to expose the location of public cameras? Are we going to be successful in our goal to increase awareness about the surveillance structures of cities?

Besides that, there is also the amount of data that should be generated by the players. Could it be an opportunity to promote awareness about surveillance capitalism? How should we deal with that data? How much of it will we have to use to manage the gameplay? How should the consent policy to be established with the players be negotiated? How can we involve them in elaborating the terms of their consent? Kerr et al. (2014) show us that surveillant assemblages and governance, in flux, respond to and shape the behavior of players in MMOGs. Stenros at al. (2012) warn us about the challenges of studying pervasive games that blur the boundaries between play and everyday life. Not only are game data in a controlled environment involved, but also the cultural context and the daily life of players. In our case there is also the context of surveillance culture. We are only in the first moment.

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Rethinking the Spaces of Standardisation through the Concept of Site

James Merricks White
Maynooth University (IE)

Abstract: This paper proposes a site-based methodology for the study of standards and standardisation. Rather than consider standards as a global phenomenon, or theorise them as a network of relations, their spatiality is rethought as an outcome of their ongoing enactment. Both the moment of a standard's implementation and its supporting apparatus are opened up to genealogical analysis using the work of feminist philosopher Karen Barad. In particular, her concepts of 'apparatus' and 'iteration' forge a link between the particularity of 'site', and the circulation and materialisation of standards. By following such an approach, a multitude of heterogeneous agencies are revealed, and with them, the potential for change.

Keywords: standards; standardisation; spatial theory; site ontology; methodology.

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Corresponding author: James Merricks White, Rm 2.07 Iontas Building, Maynooth University, Maynooth, County Kildare, Ireland. Email: james.white.2014@mumail.ie

Introduction

Standards are inherently spatial. They are spatial in their distribution. Not everyone is affected by standards in the same way, nor has access to the same standards for quality and care. What is common for the very wealthy is often completely inaccessible to the very poor (Star and Lampland 2009, 6-7). Standards are also spatial in the arrangement of the materials and behaviours they bring about. They are realised in the built environment, embodied not only in physical forms, but in the social and economic patterns of their interaction and use. Regular positions and juxtapositions seem to sediment into a technological unconscious of preindividual gesture and habit (Thrift 2004).

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The process of making something standard can be understood as a spatial operation. Sometimes standardisation occurs accidentally, as when apparently minor decisions and actions become the *de facto* way in which something is done. Many standards however are intentional and are the result of regulatory or voluntary adoption. Once a voluntary standard has been published it must be circulated and implemented. This is usually achieved through global markets, supported by promotional materials and by a normative obligation to adhere to best practice (Mendel 2006). But spreading a standard is not the same thing as ensuring that it is everywhere the same. In some instances, adherence self-regulates. This is the case with the internet protocol, IPv4. A personal computer unable to access the internet would be nearly useless – IPv4 is intrinsic to all multipurpose operating systems. Often however, it is necessary that conformity to a standard be assessed independently. In the case of ISO 9001, the dominant quality management standard, accredited third-party auditors verify compliance. Complex institutional structures and practices have been established to help assure that such voluntary standards are correctly implemented (Loconto and Busch 2010).

Given the diversity of standards and their modes of propagation, it is important that their spatial effects be addressed materially and discursively. This paper uses the concept of 'site' to open up a new approach to the spaces of standardisation. I begin by teasing out various connotations of the word 'standard'. Instead of offering a narrow and succinct definition, I define a standard as any set of rules or values which produces effects in the world. Having specified the field of analysis, I move on to the broader context of standards and standardisation by briefly reviewing relevant historical and sociological literature. In the third section, I reflect on how the spaces of standardisation have been thought about. While the metaphor of 'the network' is important, I argue that it limits the kinds of agencies involved in standardisation. I propose that the spaces of standards be reconceived using 'site ontologies' (Schatzki 2002; Woodward et al. 2010). Next, drawing on the work of feminist philosopher Karen Barad (2003; 2007), I describe one way in which this might be achieved. I argue that Barad's use of 'apparatus' and 'iteration' open up a way of linking site to the empirical study of the circulation and implementation of standards. A brief discussion of IPv4 and ISO 9001 follows, in which I give an indication of the spatial and social perspective that would be emphasised in such an approach. By rethinking the spaces of standardisation, I hope that this paper will make a modest contribution to ongoing efforts to develop social and cultural methods based on Barad's thought (Orlikowski and Scott 2015; St. Pierre et al. 2016).

1. In What Sense Standard?

Mores, manners, norms, habits, conventions, customs, traditions, standards, codes, regulations and laws are often assumed to be discrete and well-defined things. This is both a semantic and an epistemological tendency. As Busch (2011, 4) observes, these divisions are mirrored in the subject topics of academic disciplines. Anthropologists study customs and traditions, sociologists focus on norms and habits, legal scholars study laws, political scientists are interested in regulation, and so on. At a higher level of abstraction, science and engineering confine themselves to natural and technological standards, whereas the social sciences emphasise those of a social nature. The various meanings of the word 'standard' challenge the independence of these terms however. Standards traverse the social and the technological, the human and the nonhuman, and the material and the meaningful, just as they encourage researchers to cross the boundaries between academic disciplines and their topics of enquiry.

The entry for 'standards' in the Oxford English Dictionary (2017) speculates that the term's use as an exemplar of weights and measures is derived from its use as a military ensign. During battle, the king's standard stood for the central point of organisation and command. Similarly, a standard length is the object from which all lengths are obtained. Systems of measurement and calibration can be understood as organised hierarchies of authority, at the apex of which sits the physical embodiment of the measure (Crease 2011).

Standards in the singular plural (as in high standards, or double standards), signifies social norms of virtue or worth (Williams 1983, 298). This is usually what is meant when people refer to a good living standard or a minimum standard of housing. While efforts were made in nineteenth century France to codify a vital minimum level of subsistence for workers (Simmons 2015), typically this kind of standard is implied. More concrete are the standards of ethical practice adopted by professions. Medicine is the most obvious example of this, with the swearing of the Hippocratic oath, however it exists in other occupations as well. The professionalisation of electrical engineering, for example, is historically associated with the formal description and adoption of a standard of practice in nineteenth century Britain (Arapostathis 2008). Explicit occupational certification, as for accounting, is an instrumentation of this idea. Associated with this kind of standard are epistemic issues relating to the establishment of the authority of truth claims, as in the literatures on standards for justification (Boltanski and Thévenot 2006) and evaluation (for example Daston and Galison 2007; Porter 1995; Shapin and Schaffer 1985).

A standard can also refer to something pervasive or well established (such as a jazz standard or a *de facto* industry standard). This sense of the word does not refer to any individual object, nor to a set of social values or norms. It does not imply prefigurative documentation. Rather, it refers to a class of things which are standard by virtue of their general circulation and repetition. This adjectival use of 'standard' is spatial by definition.

Putting these meanings together, I understand a standard to be any set of rules or values which produces effects in the world – material and discursive, spatial and temporal, human and nonhuman, and social and technological. This definition is broad and encompasses many customs, codes, norms, regulations, laws and so on. Following Busch (2011, 26-27), I find that common distinctions between standards for humans and standards for things (and between private standards and public regulations) do not hold up to scrutiny. Rather than assume or attempt to define these as different, it is necessary to confirm their differences through close empirical examination. Just as actor-network theory proposes an analytical symmetry between human and nonhuman agencies (Callon 1986), so there is no reason to maintain an *a priori* distinction between human and nonhuman standards.

For pragmatic reasons, the two empirical examples I draw on towards the end of this paper are voluntary standards. Voluntary standards are not enforced by a sovereign state but instead are adopted by individuals, organisations and industries under their own aegis. They are also referred to as technical standards or voluntary consensus standards: technical in the sense that they are used to produce technological systems; consensus after the method of their development. Voluntary standards are developed through deliberation and consensus in specialised bodies (known as standards developing organisations or SDOs) such as the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC) and the International Telecommunication Union (ITU) (Murphy and Yates 2009; Schmidt and Werle 1998). They are published as carefully worded documents that describe objects, their encounters and (tolerable limits for) their properties. Some successful examples of this type of standard include: ISO 1161, which describes the design of corner fittings for shipping containers (Murphy and Yates 2009); ISO/IEC 7810, a standard specifying the width of credit cards (Easterling 2014); and ISO 9001, the dominant quality management standard (Furusten 2000; Gibbon and Henriksen 2011). The decision to focus on voluntary standards, rather than standards in general, is in keeping the tentative and exploratory nature of this paper. My aim is not to expand the concept of standards so much as to forward a site-based methodology for their analysis.

2. The Historical Geography of Standards

Standards have both a history and a geography. Their spread is entwined with stories of measurement and precision, voluntary professional associations, nationally-funded infrastructure projects, and the rise of global audit and management practices.

Research on the spread of metrological systems is largely historical in nature, describing cultures of measurement and comparison, and key moments in the acceptance of universal standards of equivalence (Kula 1989; Alder 2002; Bartky 2007; Crease 2011). In his story of the development of the metre for example, Alder (2002) describes the efforts of two French astronomers to accurately measure the distance between Dunkirk and Barcelona, and so calculate the circumference of the Earth. The universal metre was defined as one ten-millionth the exact distance from the equator to the North Pole and later embodied by a length of platinum stewarded by the International Bureau of Weights and Measures. Taking a broader approach, Crease (2011) draws attention to social conventions of comparison in China and West Africa, before following the story of the International System of Units through to contemporary efforts to tie measurement to universal constants. He describes how the circumference of the Earth fell out of favour as a comparator, superseded in the 1960s by the wavelength emissions of krypton-86 and in the 1980s by the distance travelled by light in a fraction of a second.

Addressing the emergence of technical standards are the histories of precision in engineering (Wise 1995; Alder 1997) and the organisational histories of the SDOs (Schmidt and Werle 1998; Murphy and Yates 2009; Russell 2014). Prior to the 1920s, efforts to co-ordinate social and technological systems were referred to as programmes for uniformity or universalism. The explicit turn to standardisation is linked to Fordism and the Progressive Era in the United States (Russell 2014), and to post-war reconstruction in Europe (Murphy and Yates 2009). Nevertheless, many of the practices involved in the development and implementation of standards can be identified earlier in the labour of machine technicians and engineers. Pressure for precisely and consistently made instruments rose gradually from the late eighteenth century, for use in both war projects (Alder 1997) and civil infrastructure (Wise 1995). Formal standardisation might be thought of as the concretisation of these tendencies into more ardent political and economic agendas. Russell (2014, 64) emphasises the leadership of the private sector in early such efforts in the United States. Standardisation, it was declared in 1926, was “a step toward industrial self-government” (Agnew 1926; cited in Russell 2014, 58) – a self-conscious industrial society was believed capable of co-ordinating and limiting its activities without state intervention. Elsewhere, standardisation is more directly connected to a push for market integration and globalisation. In the 1970s, ISO expanded rapidly under the directorship of Swedish civil engineer Olle Sturén. While he, like the Americans, believed in a values-driven economics, Sturén’s ambition was more internationalist. Co-operation with UN agencies, the European Economic Community and the General Agreement on Tariffs and Trade became a central responsibility of ISO (Murphy and Yates 2009, 20).

Empirical studies on standards are broad. For example, research has been published on standards for construction (Ben-Joseph 2005; Talen 2012), the environment (Tollefson et al. 2008; Bresnihan 2016), financial services (Porter 2005; Vestergaard and Højland 2011), food and agriculture (Dunn 2003; Bingen and Busch 2006), governance (Barry 2001; Higgins and Larner 2010), healthcare (Bowker and Star 1999; Timmermans and Berg 2003), information systems (Schmidt and Werle 1998; Galloway 2004) and management (Brunsson and Jacobsson 2000; Ponte et al. 2011). Beyond these explicit examples, it is often the case, as Timmermans and Epstein (2010) have argued, that standards skulk in the shadows of many areas of sociological study.

In keeping with the examples of IPv4 and ISO 9001, I want to describe in a little more detail some of the literature on standards for information and communications technology, and their use in the normalisation of bodies, behaviour and social organisation. For Schmidt and Werle (1998), Group 3 facsimile standards, developed at ITU in the 1980s, present an opportunity to explore where formal standards originate, how they are negotiated and the kinds of political, economic and technical pressures they must bear. Technical standards are co-ordination technologies, the authors argue, ordering and interfacing not only the machinery of exchange but also the stakeholders invested in their development. For Galloway (2004), the internet protocols TCP/IP (Transmission Control Protocol/Internet Protocol) and DNS (Domain Name System) are indicative of the distributed but nevertheless selective forms of cultural production inherent to the present political economic regime. This is reflected in the nominally open manner in which the protocols are developed and in the logics of control which they exercise. While on one level TCP/IP distributes the provision of web content, on another DNS bundles-up and recentralises the grammar by which that content is accessed. In addition to these two examples, there is an extensive literature describing the histories of telecommunications and internet standardisation (see for example Abbate 1999; DeNardis 2009; Russell 2014).

In an important work, Bowker and Star (1999) establish an agenda for the study of standards for nomenclature and categorisation. Memorably, they describe the apparatus of race classification in apartheid South Africa and the trajectories and torques it imposed on people's personal and professional lives. The programme pioneered by Bowker and Star is augmented and extended in Timmermans and Berg's (2003) *The gold standard* and in the edited collection *Standards and their stories* (Lampland and Star 2009). Additional works assembled by Brunsson and Jacobsson (2000), Higgins and Larner (2010), and Ponte, Gibbon and Vestergaard (2011) have advanced an organisational and governance perspective on process standards. Since the success of ISO 9001 in the early 1990s, SDOs have increasingly sought to use standards to formalise and promote management systems. While this might be thought of as a renewed push for industrial self-government, present-day organisational standards are conditioned by 30 years of globalisation and neoliberal policy experimentation (Busch 2011; Easterling 2014). This is less about actively undermining state power than it is about resetting its appropriate boundaries and behaviours.

The impressive breadth of historical and empirical research on standards is emblematic of their reach into social, political and economic life. Any theory of standards and standardisation needs to be sensitive to their social, spatial and temporal context.

3. Thinking about the Spaces of Standardisation

Empirical work on standards and standardisation often operates within an implied scaffolding of absolute space. Space is regarded as a framework of co-ordinates against which global, decontextualised standards touch down in local settings. This is referred to indirectly through uncritical use of concepts such as location and distance (and through the use of metric or imperial units). While this approach is usually adopted pragmatically, its underlying assumptions have been challenged by the critical social sciences. Since the 1970s human geographers in particular have explored the many ways in which space is *produced*, first through the dialects of capitalist production (for example Harvey 2006; Smith 2010) then by way of postmodern and poststructural experimentation with relational ontologies (for example Soja 1989; Crang and Thrift 2000). What these accounts share is an appreciation of space as an ongoing process, and a sensitivity to its role in social and political difference.

Rather than approach standards as an end product or established fact, this shift encourages a reconsideration of standards as unfolding phenomena. The word 'standardisation' is used to specify the process or practices by which something is made standard. In this section, I discuss two broad phases of poststructural thought on the spaces of standardisation. The first uses the metaphor of 'the network' to rethink the relationship between society and technology. The second has sought to advance spatial topologies in different terms. My preference for the second approach opens up a discussion of site ontologies.

Originating in science and technology studies in the mid-1980s, actor-network theory brackets off the ontological problem of the global and the local by focusing on the spatiality of relations. Standards are not described according to location and distance, but connective geometry. An arrangement of interacting actors is perceived as a relational network, which at a different scale of analysis might in turn be perceived as an actor. By following and describing actor-networks, practitioners hope to obtain appreciation for the complexities of the material world. Four conceptual considerations of standards as networks are introduced: Latour's (1990) immutable mobiles; O'Connell's (1993) approach to metrology; Callon's (1991; 1998) irreversibility and stabilisation; and Loconto and Busch's (2010) discussion of a tripartite standards regime. By presenting them in this order, I follow a shift in emphasis from the standardised object to the standardising apparatus.

The immutable mobile is Latour's materialist answer to an epistemological question: how is it that observations cohere and harden into fact? The example with which he introduces the concept is instructive (Latour 1990, 24). Traced in the sand, a map of a coastline is able to convey the information necessary for safe sailing. It selectively draws together the relevant relationships in a manner legible to individuals of different cultural backgrounds. But with the rising tide the map is washed away. For a map to convey its information through space and time, it needs to be written on paper, thus becoming both immutable and mobile. Rather than explain the establishment of facts using method, evidence, argument or social standing, Latour is interested in the materials and representations deployed to assemble allies to an idea. His ultimate purpose is to disclose the mechanics of scientific practice – its mundane activities which are so often taken for granted. Law and Mol (2001), in their exploration of the concept's topology, insist that immutable mobiles are situated between two spatialities: regional space, which prioritises location and relational co-ordinates, and network space, which is concerned with connection rather than position. For them, it is immutability in network space that confers the potential for mobility in regional space. The applicability of the immutable mobile to standardisation has been seized upon by Collier and Ong (2005).

In an eclectic paper, O'Connell (1993) extends the concept to help explain how systems of measurement and comparison are established. Unlike Latour, he is not interested in the persuasiveness of immutable mobiles so much as the communities of conference and exchange that are put into operation around them. O'Connell argues that metrological practices are stabilised "by establishing the authority of a particular representative, circulating it, and assuring that comparisons are made to it" (O'Connell 1993, 165). His point is that a standard is both particular and (in aspiration) universal, embodied within an indivisible object but constructed as a singular authority through the ubiquity of its relations. The appearance of universality is achieved through circulation and implementation.

Even more interested in the stabilisation of practice is Callon (1991), whose theorisation of techno-economic networks encompasses standards and standardisation. Considered as a set of heterogeneous actors bound by the intentionality of their productive methods, Callon's conceptualisation is used to explain how science and technology result from interactions between a large number of diverse components. While the paper introduces many interrelated terms, I am particularly interested in 'irreversibility' and 'stabilisation'. As networks become larger and enrol ever more numerous and diverse components, they resist mutation and change. If this proceeds far enough, a 'codified metrology' can emerge.

> Normalisation makes a series of links predictable, limits fluctuations, aligns actors and intermediaries, and cuts down the number of translations and the amount of information put into circulation. It operates by standardising interfaces – that is, by standardising and constraining actors and intermediaries (Callon 1991, 151).

In such a network, the variety of action performed by any one actor is limited. It becomes docile and predictable, constrained by the norms of the network. The irreversibility of individual practice implies stabilisation of the whole. This has implications for how standards are conceived. Emphasis is placed less on the circulation of a particular fixed actor (the standard), than on the relational fixity of a set of interactions.

Intrigued but not fully convinced by actor-network theory, Loconto and Busch (2010) set out to elaborate the politics of the institutional apparatus of standardisation. Through a discussion of the activities of the SDOs and national accreditation bodies, the authors disclose a tripartite standards regime consisting of standards-making, certification and accreditation. The deliberate act of standardisation is thus brought into relief: "Standards are the values against which people, practices and things are measured, while standardization is the process of making things standard" (Loconto and Busch 2010, 526). Callon's language of techno-economic networks is drawn on to signify the relations at play. Standardising devices are held to co-ordinate and constrain the range of activities available to actors in what is ostensibly a form of irreversibility. But the resulting stabilisation is more explicitly political than what Callon intended. The network is reconfigured as "a market economy, rather than a political or moral economy" (Loconto and Busch 2010, 527) – the space it affords is calculative and coterminous with neoliberal 'governance at distance'.

While these four approaches to standards and standardisation are subtly different, they share philosophical ground. All are materialist, empiricist and adopt a relational ontology in which the boundaries between objects blur. Accordingly, the language of absolute space gives way to a description of the geometries of association. 'Global' and 'local' are replaced by 'network', and connection is explored in terms of character and intensity, rather than location and distance. In this way, standardisation comes to be understood as a stabilisation of object-relations. This is evident in the immutability of Latour's immutable mobiles and in the irreversibility of Callon's techno-economic networks. Although this work is an important corrective to more fixed spatial imaginaries, two issues point to its limit. First, in prioritising connection, something of the presence of things in the world is lost. The vitality of matter is always at risk of being overwhelmed by the stabilisation of its relationality; the agentive potential of the chance encounter is lost. Second, and following on from this, is a tendency to bifurcate space into relational and material planes. This occurs when actor-networks are made to touch the world, as when Law and Mol (2001) theorise the topology of immutable mobiles as both regional and networked. The problem of the global and the local returns in a new guise.

Other approaches to standards have attempted to work through this problem without networks. Three are worth discussing: technological zones (Barry 2006), global assemblages (Collier and Ong 2005), and site ontologies (Woodward et al. 2010).

The technological zone challenges the opposition between national territories and the deterritorialised flows of capital. Barry (2001; 2006) defines it as a space within which technical practices have been brought into alignment. In other words, the technological zone is a space produced by the adoption of common standards. This is a distinctly political space, conceived in relation to nation states and transnational corporations. But the term evades most apprehensions of territories, markets and networks.

> Zones are not structures, territories or regions, but discontinuous spaces of circulation and regulation. They are not bounded by continuous borders but interrupted by shifting restrictions and blockages and points of conflict. (Barry 2001, 41)

Technological zones can be thought of as a kind of topology. They can overlap or enfold one another. Depending on their intersections with state and corporate spaces, they entail both technical uniformity, and social and political differentiation. While Barry (2001) maintains that zones are not fixed but always in process, demanding constant maintenance and reconfiguration, they are nevertheless path-dependent (Barry 2006, 242).

More open to disruption and dysfunction is the concept of the global assemblage, as set out by Collier and Ong (2005) in the introduction to an edited collection on the problem of global phenomena to anthropology. Here, the word 'global' refers to the capacity for something to be deracinated, transported across social and cultural fields, and take root in a new contextual milieu. This is not understood as a social operation, but rather a technical one, dependent upon material infrastructure, and administrative values and practices. A global assemblage then, is the space of interaction between a global form and the context in which it is articulated. To call such context a locality however is a mistake. Rather, an assemblage is understood as contingent and multiple; a coming together of agencies. It is therefore irreducible to a single logic. As the authors put it, "the term 'global assemblage' suggests inherent tensions: global implies broadly encompassing, seamless, and mobile; assemblage implies heterogeneous, contingent, unstable, partial, and situated" (Collier and Ong 2005, 12). A global assemblage can thus be understood as the site through which contradictions between the global and the local play out.

In an effort to rethink the spatiality of social movements, McFarlane (2009) pushes back against the 'global' in global assemblage. While he understands that Collier and Ong want to avoid confining assemblages to a particular scale, he nevertheless feels that the concept evokes the scalar hierarchy of the global and the local. As an alternative, McFarlane uses the awkward prefix 'translocal', by which he means to signify multi-sited formations through which things occur.

This position dovetails nicely with Woodward, Jones and Marston's (2010) call for ontologies of the site. Briefly stated, a site ontology is an approach to the description and interpretation of bodies in action and connection (Schatzki 2002). It is neither interested in elaborating encounters between discrete, ready-formed objects, nor in attempting to uncover deeply hidden explanatory forces. Rather, site ontologies focus on material practices and orders of meaning imminent to unfolding events. Social and spatial interpretation is conducted with a light touch, leaving open the possibility for unexpected political impulses and effects. While actor-network theory, particularly in early permutations presented here, emphasises stabilisation, site ontology takes seriously the challenge of propinquity, slippage and happenstance. Important to the argument I have been pursuing, space is not considered external to the site but an expression of its internal logics. Site ontologies therefore undermine the mediating qualities of space (whether construed as a static scaffold, a network configuration or a zone of operation), preferring to reconfigure such effects as an outcome of enactment. Put differently, in this approach the spaces of standardisation do not exert a power which extends beyond the act of their performance.

The spaces of standardisation have been thought of in a number of ways. The most intuitive is as process in which something global or transcendental affects local circumstances. In opposition to this, I have presented a handful of poststructural attempts to denature the integrity of these spatial concepts and think beyond them. Actor-network theory has long granted the spaces of standardisation critical attention. While I find its interventions important, I have argued that limits to the metaphor of 'the network' curb the potential for political agency. In an effort to open up a new analytical perspective, I have introduced the notion of site ontologies, in which space is conceived as emergent with phenomenal enactment. While this philosophical disposition has great potential for research on standards and standardisation, little has been done to develop what this might involve.

4. Towards a Baradian Approach to Standards Research

In *Meeting the Universe Halfway*, Karen Barad (2007) elaborates a metaphysics dedicated to the realism and naturalism of entangled agencies. The primary ontological unit in her philosophy are phenomena, understood as "relations without preexisting relata" (Barad 2007, 139). Within a phenomenal enactment, the intra-action (i.e., interaction within a manifold) of enmeshed posthuman agencies resolve into objects, agents, materials and meanings. For Barad, performative action precedes individuation, subjectification and their attendant physical, social, spatial and temporal apprehensions. Agency is understood as preindividual (Dolphijn and van der Tuin 2012). Surfaces, properties and identities are not inherent to objects but the result of an agential cut applied to an entanglement of relations. Thus, Barad positions the constitution of phenomena prior to the familiar structuring binaries of western thought: nature-culture, subject-object and ontology-epistemology.

Because of the primacy it affords the performative event, Barad's realist philosophy can be referred to as a site ontology (see also Barad 2012). Barad does not use the term site however, preferring to approach spatiality through the concept of the 'spacetimematter manifold'. The term 'manifold' originates in the mathematical field of topology and here signifies a non-Euclidean, multidimensional space of relations. For Barad, matter and meaning are assembled within the manifold, their complex connections and disjunctions expressed in an imbroglio of twists, knots and breaks. She describes the spatial arrangement using the metaphor of bread dough:

> Imagine putting drops of colored dyes into a piece of bread dough. As you knead the dough, the dyes spread out in different patterns of entangled lines and surfaces. But this process is too tame… the changes are all continuous and the dough maintains its topology. So break off some pieces and reattach them to different areas and continue kneading. Take a different kind of dough and make a different manifold with different lines, surfaces, and volumes of colour. Intermingle the dough pieces: new entanglements form, new possibilities emerge. (Barad 2007, 439, note 85)

As an event takes place, the manifold is cut, producing the subjects, objects, spacings and timings so familiar to everyday experience. Materiality, spatiality and temporality are all a result of the expression of the manifold.

Within a Baradian framework, the context of a standard is approached as a 'material-discursive apparatus of bodily production'. This wordy concept needs unpacking. First, the hyphenation of the 'material' and the 'discursive' acts to recognise their ontogenetic entailment and mutual irreducibility: "Neither discursive practices nor material phenomena are ontologically or epistemologically prior. Neither can be explained in terms of the other. Neither is reducible to the other" (Barad 2007, 152). For Barad, it is important to appreciate the agency of matter in producing effects in the world. Second, where Foucault (1980, 194) used 'apparatus' as a way to map out the discursive and nondiscursive practices which give statements meaning, Barad uses the term to encompass the Foucaultian apparatus *and* the apparatus of the scientific experiment. Barad asserts that all scientific experimentation enlists intangible and often unanticipated cultural relations (such as the knowledge and experience of the technician, the most recent outcome of funding applications and the general mood in the laboratory), and that broader social norms and practices are historically interwoven with the vitality and dynamism of matter (that it would be a mistake, for example, to discuss gender without acknowledging the constitutive potential of human bodies, reproductive technologies and health care institutions). Again, the purpose is to acknowledge the mess of agencies swept into the manifold. Third, 'bodily' is used generally. It refers in the first instance to human bodies and other individuated physical bodies (including those of nonhuman lifeforms, technical instruments, land masses, *etc.*), but also might be extended to cover cultural and social bodies (e.g., bodies of text or the body politic). It is intended, following Foucault (1977), to foreground the sites on which power works, but following Haraway (1988), to emphasise the ontological and objectivist ambition of the concept. In summary, the 'material-discursive apparatus of bodily production' is the imminent structure which iteratively configures the agential cut made to the manifold. It includes discursive practices but is broader than them, also encompassing the productivity of nonhuman agency and the manifold on which these things go to work.

To bring Barad's apparatus in closer alignment with a study of standards it is necessary to drill down on another concept she deploys: 'iteration'. For Barad, bodies are continually materialised and identified through the *repetition* of their formative practices. This is encapsulated by 'iterative citationality' which is borrowed from Butler (1993), who in turn adopts it from Derrida (1974; 1988). Iteration is not simply the repetition of the same. Rather, it signifies the difference or modification entailed in repetition. While an iteration necessarily carries something of the same, such that it can be recognised, it nevertheless opens up the possibility for something new (Cuddon 2013, 373). Derrida understood this principally as an operation of words and concepts. Thus, in speaking we cite previous utterances and conceptualisations. But through Butler and Barad, the term takes on new meaning. Specifically, it refers to the working and reworking of power on bodies, and to the configuration and reconfiguration of cuts on manifolds. As such, the *historicity* of matter in its enactment is brought to the fore.

Having laid the groundwork, it is possible to move on to a discussion of methodology. Barad advocates a kind of social analysis referred to as a 'genealogy of the material-discursive apparatuses of bodily production' (Barad 2007, 451, note 25). For the most part, her use of 'genealogy' adheres to the method developed by Foucault (see Dreyfus and Rabinow 1983). It is necessary to mark two key differences however. The first pertains to her posthuman performativity. The second to her conceptualisation of power.

The weakness of genealogical accounts, according to Barad, is that they tend to overemphasise epistemology. By focusing on the ways in which things in the world are known, rather than the things themselves, human and nonhuman agencies are collapsed into a concern with representation. Materiality is thereby rendered flat and unresponsive. This plays out differently in the work of Foucault and Butler. When Foucault discloses a productive apparatus it is too steeped in the realm of meaning (Barad 2007, 65). The body does not push back against the iterations of power inscribed upon it. While Butler is better on this front, opening up a discussion of the agency of bodies, according to Barad (2007, 145) her genealogy is too anthropocentric. The attention given to the production of human bodies crowds out the nonhuman from the performative event.

An approach more balanced than Foucault's or Butler's would refuse to give preference to human agency over nonhuman agency and meaning over materiality. Barad (2003) theorises this as 'posthumanist performativity'. Two strands of feminist thought are being drawn on here. While the origins of the concept of 'performativity' can be traced to J. L. Austen's theory of speech acts, wherein an utterance consummates an action (Sedgwick 1993) – "I now pronounce you husband and wife" – Barad is more explicitly citing Butler (1990; 1993), whose focus is the association between the performativity of gender and the production of sexed bodies (Barad 2007, 413, note 39). Over the last two decades, the term has been used widely to signify the *effects* of a set of ideas, logics or discursive practices (Butler 2010). As such, performativity allows genealogy to move beyond representation into a description of things in their becoming. The posthumanism evoked by Barad is inflected by the antihumanism of Foucault and the cyborg imaginary of Haraway (1991). It refers not only to a deconstruction of liberal notions of the human subject but to a positive statement on the kinds of things that are able to act. For the posthumanist, agency must be extended to matter in all its forms and not be limited to human (or to ecological) life (see also Bennett 2010; Braidotti 2013). To adopt a posthuman perspective on performativity then, is to perceive material phenomena and meaningful effects as the outcome of action amongst a complex and heterogeneous mess of agencies.

Before she can fully advocate for a Foucaultian genealogy, Barad needs to account for the operation of power. This is achieved, in part, through her discussion of the monograph *Producing Workers: The Politics of Gender, Class, and Culture in the Calcutta Jute Mills* (Fernandes

1997). This ethnographic study explores in detail how structures of class, caste and gender are cited and enacted. Sociological forces are not held to be transcendental to the affects and practices of the workplace but immanent to them: expressed in positions and activities; marking bodies in overlapping and interpenetrating ways; reworked by the meanings and representations with which they are understood (Barad 2007, 229). Foucault's interpretation of power is thus used to reset the terms of the structure-agency debate. Rather than act in an all-encompassing and repressive manner, structure is brought into the manifold as force relations or social alignments (see also Wartenberg 1990). Power does not stand above (or before) things and events. Instead it refers to the sedimentation of (re)iterated agential cuts and to the breadth of effects that are thereby produced: "the forces at work in the materialization of bodies are not only social, and the materialized bodies are not all human" (Barad 2007, 235). Barad approaches power as a Foucaultian but is interested in opening it up to nonhuman agency and to an analysis of (ontologically flat) social structures. Thus, in conducting a genealogy of workers in a jute mill, the material-discursive apparatuses of bodily production which condition powerful effects in the workplace are subjected to the interpretive analytics of Foucault's method.

As human agency is always already caught up within the manifold, there is no possibility of standing outside. The researcher is entwined with their object of study; indeed, they are produced through their intra-actions with it. To see, listen and reveal are all deeply ethical activities. Similarly, Barad is careful to assert that the manifold is open-ended in the sense that there remains the possibility for political change. Human agency is only part of any one mattering but it is a part. In every phenomenon there is an opportunity to effect when, where and how the agential cut is made. But that potential is not boundless. Rather, Barad (2007, 147) envisages a field of possibilities and impossibilities, a multiplicity slowly configured and reconfigured through reiterative enactment. In becoming political subjects, we affect the objects and relations with which we are co-constituted, an act which in turn affects subsequent iterations.

To summarise, the suitability of Barad's metaphysics to the study of standards rests on three theoretical moves. The first is the foregrounding of the site of enactment. Rather than depend upon spatial metaphors external to the event of a standard's implementation, space is conceived as an ongoing process. This rejects the static co-ordinates assumed by the majority of standards research but exposes a rich mix of productive agencies. There is a risk that by fixing analysis upon the moment at which a standard is implemented, how the standard came to be is ignored. Stabilisation could become of greater significance than circulation. But this risk is diminished by the second move: acknowledging the importance of iteration to the process of standardisation. By recognising that standardised practices cite previous articulations and instantiations, this trap is avoided and the historicity of a standard is fully exposed. But iteration involves 'the same' as well as 'the different', just as standardisation does entail some form of repetition. Hence, with the third move, the stabilisation of a standard is understood through Foucault's conceptualisation of power. Standards are not inherently powerful but can become as much through their circulation and implementation. A widely-adopted standard can thus be thought of as an alignment of discursive and nondiscursive practices or a sedimentation of the cuts made by an apparatus of bodily production.

Standards are not only the rules and values which bring order to a messy world, but also must include the more-than-human context through which those standards were developed and are continually brought about. As such, the event of a standard's implementation should be approached as an ontologically transgressive entanglement of presences and absences, materials and meanings, and natures and cultures. It is only through iterative enactment that this apparatus acquires the power to enforce the neat categorization of things. Thus, Baradian analysis entails a description of the materialities and meanings of a standard's site of implementation, combined with a genealogical interpretation of its conditioning apparatus.

5. Rethinking IPv4 and ISO 9001 through the Concept of Site

Robust genealogy demands patient and detailed description. Given the space remaining, it is impossible to fully achieve this here. Nevertheless, I want to give an indication of the spatial and social perspective of material-discursive genealogy. IPv4 and ISO 9001 serve as my examples.

5.I. The Site of the Internet

When a data packet is sent between two computers using the internet, it is structured according to a document published by the Internet Engineering Taskforce in 1981: Request for Comments (RFC) 791. In this document, expectations for the metadata contained within a data packet are described. What to include, what to leave out and how many bits to allocate each data field were all debated in the months preceding the publication of the RFC. This was further conditioned by the expertise of engineers working on the internet protocols, their institutional and organisational affiliations and the generous funding programme afforded them by the National Science Foundation (DeNardis 2009). The result is a text that is seldom read, but exceedingly powerful. According to a Baradian approach, whenever IPv4 is enacted, RFC 791 and its history (including the politics of its development and dissemination) are cited and enfolded into the site.

While the internet is commonly perceived as a network, Barad's metaphysics open up an alternative perspective. Whenever data are sent using IPv4, the protocol and its context, conceived as an apparatus, coalesce with the particular agencies of the data packet – the bits which code for it, the computer hardware which supports it, the cables between its origin and destination, the desires initiating its transmission and the partial meanings it carries. All of this is bound together into a relational knot (what I refer to as a site and Barad a spacetimematter manifold), only to resolve into the signal, its spatial arrangement, its timing and its cultural associations. Construed as such, the internet is less a network than an outcome of the citation and realisation of IPv4 and the other internet protocols. In this inversion of the usual spatial logic, the network is interpreted as a performative spatial effect of continuous and ongoing materialisations.

But what is the purpose of this inversion? First, it reveals the variety and heterogeneity of constitutive agencies. The internet does not arrive, stable and fully formed, at a site of encounter. Rather, it is produced from a multitude of material and discursive agencies. Second, the Baradian inversion allows – on a theoretical level, at least – a wide ranging discussion of constitutive relations, and social and political outcomes. In the example of IPv4, the infrastructural trajectories are so well established that what occurs seldom deviates from what is expected. The field of possibilities is so narrow that the protocol and its context appear to fall away. To inventory them as I have begun to do seems speculative, if not pedantic. Nevertheless, a strength of Barad's metaphysics is in the way this background is brought into view.

5.2. The Power of (Re)iterative Quality Practices

ISO 9001 is used to establish quality management systems. Firms seeking compliance are required to formerly document their quality practices and show proof of their adherence to them. The standard does not define how a firm should go about producing products and services, but offers an adaptable set of management principles to help expose and regularise existing business processes. Effectively, it creates a paper trail, extending the reach of auditors to include the *activities* of industry, along with its outcomes.

Given its flexibility and its focus on process rather than performance, the event of ISO 9001's implementation is difficult to isolate. The standard is most obviously cited in the initial formulation of a firm's quality documents. Nevertheless, it would be a mistake to limit ISO 9001 to a realm of representation. It makes more sense that the standard should be described as operating in a fragmented, multiple and incomplete manner.

I therefore understand any business practice for which a formal document exists to also be an enactment of ISO 9001. Certainly, the agency of the standard within such a site will always be partial; its ability to structure and order outcomes will depend on the circumstance. But the power of ISO 9001 is to be found not in the paper trail it produces, so much as in the ubiquity, frequency and subtlety of its effects. As such, a Baradian analysis of the standard draws attention to the molecular and accumulative manner in which power operates.

Through its many sitings the historicity of ISO 9001 is continually brought to bear on the present. This includes both the development of the standard and the steady intensification of its use. ISO 9001's text originated as a mid-1960s quality standard to promote multilateral contract sharing and outsourcing between NATO nations (Gibbon and Henriksen 2011). From here, it was adopted by the UK Ministry of Defence and found its way into British Standard (BS) 5750:1979, before being discussed at ISO in the mid-1980s. The ascendency of the *logic* of quality management is more general than this and has been linked both to the presence of US management consultant W. Edwards Deming in post-war Japan (Murphy and Yates 2009, 72; Busch 2011, 129) and to the backlash against Japanese industry's later incursion into Western consumer markets (Higgins and Hallstrom 2007). Whether by one route or another, the discursive and nondiscursive practices of quality management were long in circulation before the publication of ISO 9001 in 1987. Nevertheless, the sense of objectivity and authority granted by the ISO has legitimised the culture of quality assurance (Mendel 2006).

Perhaps a word of caution is in order. There is a risk of overplaying the distinct agency of ISO 9001 when describing the rise of quality management. Many structuring dynamics are implicated in the material-discursive becoming of quality practices, not the least of which is the neoliberal urge to maximise market information through a regime of quantification, calculation and accountability. While material-discursive genealogy reveals these broader cultural trends, emphasis ought to remain on their operation within the site (i.e., their intersections with ISO 9001 and other local agencies to bring bodies and subjectivities into being). The particular attraction of standards is that they help disclose the shape and intensity of such functions of power. Rather than understand quality management as a transcendental ideology, a Baradian approach breaks it down into a series of practices which, through repetition, rework what can be meaningfully said and done.

Conclusions

This paper has argued for a reconsideration of the spaces of standardisation using a site-based methodology based on the work of Karen Barad. Rather than conceive of standardised objects as moving and interacting *in* space, it has advanced a position in which space is produced alongside material enactment. Standards are thus understood as an ongoing achievement of powerful apparatuses. By rethinking standards through the concept of site, they are opened up to a diverse range of material and discursive agencies.

My sample of what a Baradian material-discursive genealogy of a standard would involve is limited in two respects. The first is the brevity of these accounts. Genealogy involves the slow and patient description of material, social and historical associations. What I have presented does not try to achieve that. The second is the pragmatically bounded approach to standards. I consider voluntary standards to be a subset of what the concept of 'standard' entails. As such, the need remains to both offer a thorough genealogy of a voluntary standard and to attempt to flesh out how the methodology might be extended to standards in general. The purpose of this paper has been to lay the groundwork for how this might be achieved. Nevertheless, from the two examples presented, I hope to have shown that the methodology offers an interesting perspective on the spatial forms of dispersed infrastructure, and on the shape and intensity of power in cultures of corporate auditing and management.

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Data Platforms and Cities

Anders Blok
SODAS University of Copenhagen (DK)

Antoine Courmont
Sciences PO, Paris (FR)

Rolien Hoyng
The Chinese University of Hong Kong (CN)

Clément Marquet
Télécom Paris Tech (FR)

Kelton Minor
SODAS University of Copenhagen (DK)

Christian Nold
Univesity College London (UK)

Meg Young
University of Washington (US)

Abstract: This section offers a series of joint reflections on (open) data platform from a variety of cases, from cycling, traffic and mapping to activism, environment and data brokering. Data platforms play a key role in contemporary urban governance. Linked to open data initiatives, such platforms are often proposed as both mechanisms for enhancing the accountability of administrations and performing as sites for 'bottom-up' digital invention. Such promises of smooth flows of data, however, rarely materialise unproblematically. The development of data platforms is always situated in legal and administrative cultures, databases are often built according to the standards of existing digital ecologies, access always involves processes of social negotiation, and interfaces (such as sensors) may become objects of public contestation. The following contributions explore the contested and mutable character of open data platforms as part of heterogeneous publics and trace the pathways of data through different knowledge, skills, public and private configurations. They also reflect on the value of STS approaches to highlight issues and tensions as well as to shape design and governance.

Keywords: data platforms; data labour and reuse; environmental sensors; urban governance; transparency.

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Corresponding author: Anders Blok, Department of Sociology, University of Copenhagen, Øster Farimagsgade 5, Postboks 2099, 1353 København K, CSS - Building: 16.1.58. Email: abl@soc.ku.dk

Towards Data-driven Urban STS?

Anders Blok and Kelton Minor

Whenever new and power-laden techno-political projects emerge, science and technology studies (STS) should consider itself invited to the fray. In recent years, visions and materialities of data-driven (so-called) 'smart urbanism' have come to constitute such a project, with consequences petit and profound for urban governance around the world. Against a backdrop of increased datafication, whereby daily personal routines in the city now generate digital traces in granular detail, public and private urban actors seek to harvest, process, refine and serve up civic data to power their decision-making processes. As STS researchers, it is tempting (to say the least!) in this situation to dust off still-valid critiques of technological determinism and to re-deploy long-standing analytical commitments to socio-technical contingency in city-making, whether of the urban technological frames, politics of urban design or heterogeneous urban assemblage variety (see Farías and Blok 2017). However, what does one do upon realizing that socio-technical contingency is just what urban authorities are looking to *harness* and *extend* through the deployment of new data formats, techniques and infrastructures embedded into the urban fabric?

In this short reflection piece, we want to deploy a local and perhaps parochial example, drawn from our own recent research experience, in order to raise some more general questions about the stakes of STS in data-driven urban governance. The example in focus pertains to a set of urban ambitions, coordinated in and around the municipality of Copenhagen, Denmark, to extend its commitment to cycling as a climate-friendly mode of transportation via the 'smarter' planning capacities conveyed by 'bigger and better' data on bicycle mobilities (see Boellstorff and Maurer 2015). More precisely, we want to dwell on a specific participatory event, in which planners, consultants, businesses and researchers from several European cities – ourselves included[1] – were invited to assist the Copenhagen municipality in thinking through its data-infrastructural options and imagining, purportedly, innovative solutions.

Two conditioning parameters of this event immediately stand out. First, the way data and its promises are harnessed and channeled in this setting must be seen as responding to a quite *specific* situation of urban governance in Copenhagen, a city keen to extend its transnational 'front-runner' position in domains of bicycle infrastructures, in particular, and urban greening and low-carbon transition more generally (see Blok 2012). In this

[1] In actual fact, only one of this text's authors (Kelton) participated in the event. While the intricacies of our own research trajectory matter to our story, and will be briefly recounted later in the text, for the sake of convenience – and to convey a point about positionality – we write here mostly in the homogenized voice of a 'we'.

sense, the event exemplifies how capacities of data to exert effects within urban governance are likely to be strategically co-shaped by a whole range of situated urban realities, interests and trajectories, which come to be latched onto and nested within each other. Indeed, a long history of STS reflection on infrastructures (e.g. Star 1999) would lead one to expect as much: new data infrastructures are perhaps less what 'drives' urban governance as what may come to exert effects in wider, more distributed and more layered assemblages of urban techno-politics. In a city like Copenhagen, such data assemblages have latched onto bicycle, low-carbon and other existing urban infrastructural projects.

Second, as should be clear, our own situated format of engagement with this setting, as researchers working on data and urban-related issues at the University of Copenhagen, is one of interiority and participation rather than external observation. To start with, this is not so much a matter of us, as 'proto-STS' urban researchers, striving to make a reflexive point.[2] Rather, it is more about how our own everyday research trajectories have constituted us, in the midst of doing other things and being 'otherwise engaged' (Harvey and Knox 2008), as now belonging to the diverse field of 'knowledge-based stakeholders' with something to contribute to the 'technical' side of the Copenhagen event. More generally, we might say, it has to do with how specific forms of interdisciplinary research, in one capacity or another, are *already* integral to the ongoing 'infrastructuring' (Dantec and DiSalvo 2013) of such data relations in the service of local urban change and emergent publics.

The point we wish to make on this basis is less one of action-oriented STS being involved in self-conscious intervention in this field of urban practice, nor one of the performativity of STS across domains of techno-scientific politics in general (see e.g. Zuiderent-Jerak and Jensen 2007). It is a much more modest and situated point, related to a reflection on how it is that our own collective research trajectory has come to be relevant to other actors, with other agendas and concerns, in this particular urban milieu (as Isabelle Stengers would term it) – and conversely, how this milieu has come to be relevant to our research (see Savransky 2016). As we will suggest, this event of relevance seems to us to pertain to the *specific* ways in which technical, political and ethical aspects co-implicate each other in this milieu of data-driven urban governance, with implications also, we argue, for how STS might envisage its own stakes in it.

To briefly set the stage: the participatory event in question, called the "Big Data for Cyclists Workshop", took place in the House of Innovation in Copenhagen on February 15 2017, under the joint auspices of the municipality's Technical and Environmental Administration and the so-called Climate-KIC Nordic network, a public-private innovation partnership

[2] We return towards the end to the notion of 'proto-STS'. Suffice to say that it is meant here to hint at the ambiguities of knowing, on our part, when 'STS' starts and stops in an interdisciplinary research setting such as our own.

sponsored partly by the European Commission. Evidently, in a context of mushrooming 'living laboratories' for urban sustainability transition (Evans and Karvonen 2011), and the way these intersect with location-sensitive data technologies for the production of 'speculative' urban futures (Leszczynski 2016) and the participatory design of new public 'things' (Dantec and DiSalvo 2013), this workshop is easily recognizable as one version of a more general pattern. What interests us here are some details of the staging of data promises during the workshop.

From the outset, municipal organizers were adamant to frame the workshop around an unfortunate asymmetry of traffic planning: whereas Copenhagen planners are in possession of fairly detailed locational data on car- and bus-based mobilities in the city, no comparable data exists for those roughly 41% of trips undertaken by bicycle. Stated otherwise in the city's supporting information brief, while sensors around the city count aggregate bicycle numbers, this data allows for no extrapolation on routes and trip times needed by the city to respond to "congestion, accidents, stalled cars/lorries parked on bike lanes, road works exceeding their permits, debris, and unplanned events" that can inconvenience "tens of thousands of cyclists" that use the city's central corridors each day. In the face of strong political commitments to increase the share of bicycle-based traffic to 50% by 2025, planners thus face an obvious challenge: how to optimize interventions aimed to improve bicycle infrastructures – and, correlatively, the attractiveness of choosing bikes over cars – with little solid information on current bicycle practices.

In short, the promises of data staged in the workshop were politically infused from the start, framed within a specific narrative of low-carbon transition in Copenhagen traffic planning. Notably, however, the potential perils of privacy violations were absent from the organizers' stated list of criteria by which ideas solicited from external stakeholders would be judged. Indeed, to help solve this planning-based challenge through 'bold' and 'radically innovative' uses of urban data was the very mandate through which the organizers elicited data experts (ourselves included) for participation in the workshop.

Concretely, prior to the workshop, each participant had to submit a brief pitch of her or his prototype 'big data for cyclists' idea. At the beginning of the workshop, these pitches were then enacted by their creator(s) for an audience of both in-person attendees along with remote viewers watching via video links from a small constellation of universities and workplaces scattered across Europe. Towards the end of the day, a judging panel – consisting of, among others, a former Danish minister of traffic and the Dutch ambassador to Denmark (!) – selected three prototype ideas for further concept development.[3]

[3] We mention this to signal how the workshop was also trans-local in ways reflective of specific and competitive urban geographies of 'advanced' bicycle infrastructures, such as those found in major Dutch cities.

More of a platform for competition than collaboration, the workshop floor was thus a bazar of self-contained data-promises rather than a space for creative cross-fertilization and experimentation (contrast Perng, Kitchin and Evans 2016). This tension between modes of engagement was further enacted when the event organizers instructed participants (ourselves included) to physically root themselves in different parts of the room to develop their ideas independently. In our experience, this physical displacement and separation formed individual islands of interest visible on the floor and constrained the melding of isolated concepts – an observation also duly noted by one of the judges at the event's conclusion. Hence, while participatory in name, the workshop enacted its own specific modes of (non-)cooperation.

The fact that we found ourselves in this workshop situation speaks to a certain intersection with our own collective research trajectory – albeit, like much else in this rather heterogeneous setting, that the connection is orthogonal and indirect, rather than fully cooperative (so to speak). For a number of years, we have both partaken in a large-scale interdisciplinary research project known as the Copenhagen Social Networks Study, involving anthropologists, economists, philosophers, physicists, psychologists, sociologists and others.[4] Set up via a self-built data infrastructure, the project deploys mobile phones as devices for studying social networks – via call and SMS logs, Bluetooth and Wi-Fi records, GPS coordinates and so on – among a freshman class of approximately 800 engineering students at the Danish Technical University (DTU), located north of Copenhagen. As such, it joins the emerging frontier of digital trace-based computational social science, while at the same time experimenting ethnographically and otherwise with the many ethical and political questions thereby opened up (see Blok and Pedersen 2014).

Accordingly, while the Study branches off in many different substantive directions, one recurrent theme reverberating through our interdisciplinary dialogues has taken the shape of a participatory, 'proto-STS' interest in the infrastructural technicalities and the political ramifications of data ethics. From the very construction of privacy-protecting databases and data practices at DTU, data ethics has increasingly and recursively become a research topic in its own right for members of our group, as we have sought also to build relations beyond our academic platform. More than this, an ability to speak credibly on data ethics issues has emerged as something of a *resource* for us, as we have realized the sheer salience of such issues amongst everyone from architects to municipal planners. In short, as a team, we have gradually come to inquire into what an ethical data infrastructure might be and what it may become.

[4] Over the years, the project has carried several names, including SensibleDTU and Social Fabric. Most recently, it forms the backbone of the Copenhagen Center for Social Data Science (SODAS), where this text hails from.

Set within such a generative trajectory, the big data idea submitted for the bicycle workshop by Kelton Minor (co-author of this text), on behalf of our research team, might be said to reflect a collective realization, very much along STS lines, as to the inseparability of technical, ethical and political dimensions when dealing with any digital data infrastructure. The idea, in essence, would be to build on lessons learned during the DTU study on how to use mobile phone-based GPS and Wi-Fi traces to trace bodily mobility routes in sufficiently granular ways to also infer the means of transportation (i.e. bicycles). Such database building would be enabled, in turn, via a two-tiered infrastructure, one based on 'passively' recording anonymized, randomized and encrypted mobile device IDs and the other based on 'actively' eliciting civic data donations from citizens via an opt-in mobile app as an emergent form of urban volunteerism. Together, the two data-eliciting techniques would provide a proprioceptive picture of aggregated bicycle activity patterns in order to assist the city to sense how citizens are using its extensions (and the hurdles they encounter in doing so).

Through the app-based data donations, this approach activates an element of citizen science, thus working towards engaging urban data citizens and publics into the forging of the algorithmic bicycle city (Paulos, Honicky and Hooker 2009). Conversely, as is immediately obvious, the key to the passive recording of mobile device data and its further processing for planning purposes is how this infrastructure would deal with privacy issues and concerns given the granularity of the data. Here, automated processes of de-identification and randomization ensures that a high level of privacy protection is, so to speak, *built into* the design of the data infrastructure from the outset. Figuratively speaking, the infrastructure works as a community garden-like data commons: while data remains only personally accessible for each individual owner's 'plot' (via app-based data feedbacks), the municipality attains an in-principle de-identified, aggregate overview of the entire 'garden' (the city bicycle infrastructure).

From participating in the workshop, it became clear that such a striving for ethically sensitive data infrastructures is by no means a foregone conclusion: other proposals, coming from private data consultancies, would for instance build on face recognition and re-identification techniques from a network of local cameras at traffic-intersections, with little attention to issues of data storage and potential misuse of the powerful responsibilities associated with the capacity to re-identify individuals. Indeed, as noted, privacy protection was initially *not* featured among the criteria of judgment in the workshop competition – something we called attention to during the workshop, as the organizers presented the criteria. On the other hand, when alerted to the latent issues, planners, judges and others proved susceptible to their importance, to the point of this becoming a stated reason as to why our idea was selected for further concept development. In this sense, the workshop itself emerged as a kind of 'proto-STS' event, in which the co-shaping of data techniques with ethical concerns came to be partially recognized and embedded into the city's ongoing proposal formation.

The fate of our prototype big data-for-cyclists idea remains yet to be decided within the involved public-private settings of Copenhagen's governmental entities. As such, it is once again in the hands of more powerful others, pursuing mixed agendas and oriented to additional rationales beyond just our collective research intentions and values enacted in the Copenhagen Social Networks Study. Likewise, it remains to be seen what kind of relevance this foray into the milieus of data-driven urban governance will attain in our future research endeavors (this short text constituting of course only a preliminary start to be sure). So far, we count it as confirmation on our part that a certain sensibility to the contingent co-shaping of the material and the social, the technical and the ethical, within data infrastructures is fast becoming not only the *topic* of urban STS, but also – and this is the point we have wanted to make – a potential *resource* for its further development.

As such, while acknowledging the risk of parochialism and self-indulgence, we have attempted in this short piece to deploy our own situated experiences in the service of perhaps eliciting something critically general: what might a data-driven urban STS come to look like? In this sense, we have attempted to use the Copenhagen workshop also metonymically, as a placeholder for all those relatively underdetermined, inquiry-conducive and awkwardly engaged encounters and distributed spaces that are *also* part of the power-laden and otherwise over-coded landscape of smart urbanism and data governance. We further suggest that, far from being marginal to such spaces and encounters, STS insights into socio-technical contingency might be seen as entirely integral to them – provided, that is, that we as STS researchers are willing to have our 'proto-STS' insights shared across more heterogeneous assemblages of interdisciplinary relations and to recognize their localized embedding in specific urban contexts.[5]

If data is always a contingent socio-technical relation, then a data-driven urban STS might be that endeavor which takes such relations and their urban infiltrations as its own starting and ending point for research, experimentation and critique. Like other forms of digitally informed research, it would constitute an 'interface method' (Marres 2017), shaping up in an as-yet indistinct space of interdisciplinary and extra-academic engagements in the city. Along the way, it will have to come to terms with novel entities and relations, including those emerging urban data publics that remain for us so far only on paper. Plenty of scope persists, then, for improving on this first beta version of data-driven urban STS. We hope other passengers, and drivers, will want to join in the fray to explore the epistemic, technical, ethical and political ramifications that encompass this incipient crossroads.

[5] As should have become clear, this text is itself the product of such an interdisciplinary writing encounter, as it reflects the joint research commitments of two authors who are *also* otherwise engaged with data and the city.

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Open data re-use and data frictions. The tension between attachment, detachment and reattachment.

Antoine Courmont

Open data and smart cities policies underscore the implementation of the ideology of information liberalism into the urban government. This ideology was theorized by the French scholar Benjamin Loveluck through a political genealogy of Internet (Loveluck 2015). He claims that information is at the core of contemporary liberalism. Information must circulate freely in order to solve various problems in the context of cybernetic theories. The information liberalism is based on the assumption that data exist, are autonomous and can easily circulate.

Based on an ethnographic investigation inside the Metropolis of Lyon (France), I question this assumption. Indeed, the analysis of the open data policy *in the making* reveals a tension between attachment and detachment that needs to be addressed to allow a smooth circulation of data (Courmont 2016). Attached to vast socio-technical networks, data must be detached from their initial environment to circulate, before being re-attached to new users. Following traffic data from its production to its reuse (a perspective similar to a data journeys approach (Bates, Lin, and Goodale 2016), I will consecutively highlight the attachment between data and local transportation policies, the trials of detachment to make data circulate, and the data reattachment to secondary uses. The description of each of these steps illustrates how open data transform urban government.

Attachments: produce traffic data

Data are never autonomous neither immaterial. They are always entangled with and gifted by a collective of objects, people, techniques, ideologies, etc. Data are composed of various attachments (Gomart and Hennion 1999), which form a sociotechnical network made of heterogeneous entities. For instance, traffic data are part of a long chain from road sensors to traffic lights remote control in real-time by a specialized team inside a central control room. Algorithms, fiber optic network, data storage and even the traffic regulation policy cannot be separated from traffic data.

These attachments are never neutral: they do something. In this case, the traffic data produces a specific representation of the city that is used to regulate the road network. Indeed, data are based on conventions (Desrosières 2002), which define what must be represented to meet a specific use. The road network is not represented in its whole. Only some road sections are represented: the ones where the local authority want to tackle traffic congestion. That's why data are not only composed of attachments, but they also attach. They produce a link between a specific representation of the city and an actor who acts on it. In this case, traffic data attaches the local transportation authority to its network through a convention defined to regulate road traffic.

Detachments: make traffic data circulate

To make data circulate, it is necessary to recompose the sociotechnical network of the data by untying some associations – the detachment – and constituting new ones – the reattachment. Indeed, the challenge is not to make data autonomous, but to ensure it can be well-attached to new users. The process of opening data is the result of a series of uncertain trials, during which the characteristics of the data, the producers and the users, are simultaneously re-defined. These *trials of diffusibility* recompose the sociotechnical networks of the data. To detach data from their initial environment, their previous ties are questioned in the light of their future attachment to prefigured users (Akrich 1992). This process changes the data. Moving from a trial to another one, data differs by the network it deploys. Data as stable and unchanging entity is a fiction.

While open data activists ask public bodies to release their data without thinking about the re-uses, in practice, prefigured users are constructed by the producers to decide to open or not their data, and, especially, how to open it. These usage scenarios vary depending on the producer or the data. A common fear is the risk of misuses or uses that may backfire on them. As instance, as Martin - a data producer - told me:

> We do not want to cause any trouble to some projects defended by our colleagues. For instance, what if some people misuse historical traffic data to oppose infrastructure projects? Indeed, data may be used in the right way, but, these data are very technical, and it could also be quite difficult to interpret them correctly.

These prefigured uses determine the sensitiveness of the data. To overcome reluctances of the producers, the perceived risks are weighed by potential gains. Beneficial scenarios are also constructed and allow the detachment of the data from its initial environment and its attachment to new users. For instance, the open data project leaders often took as an example the case of a carrier using traffic data to optimize his delivery journey is often put forward, a re-use of open data aligned with the public policy.

Not only these prefigured uses determine if the data will be released, but they also affect the characteristics of the released data. Indeed, data are always shaped to meet a specific purpose and/or constrain certain uses. Data are transformed before their release to make possible the detachment from their production infrastructure and to facilitate their reattachment to new users. This process of "rawification" (Denis and Goëta 2015) of the data is the result of discussions with users in order to sustain the attachment with them. For instance, traffic data were initially published in the form of traficolor to ensure the coherence of information and to avoid misuses. However, after exchanging his views with some academic users, the producer has decided to release a "rawer" data which now include occupancy and flow rates.

The release of data is the result of a simultaneous process of detachment of the data from its information infrastructure and its attachment to a new environment. Nevertheless, on the contrary of the processes of innovation analyzed by Goulet and Vinck (Goulet and Vinck 2012), the release of data does not imply the dissociation of all the ties linking the data and its initial environment. Firstly, because the data continue to be daily produced and used by public organizations. Secondly, because the attachment to new users cannot be successful if the data is fully detached from its initial environment: data will not be actualized, etc. That's why the challenge of opening data is to achieve dealing with this tension between detachment and attachment.

Reattachment: re-use open data

In order to follow the chain of open data, we need to analyze their use by external actors. Far from enthusiastic hopes of economic development and democratic renewal, the first evaluations of open data policies noticed the relatively low uses of released data. A French open data advocates noted in a blog post in January 2013:

> organizations are going through a period of doubts and depression: the data blues. […] the multitude of technical, juridical, cultural and organizational challenges have left a bitter taste in the mouth of data re-users" [6].

This reaction highlights the fact that an offer of data does not automatically meet a demand of data. The reuse of data raises coordination issues between heterogeneous social worlds. A lot of operations of cleaning, crossing, standardizing or articulating data are required to allow their attachment to a new information environment. While some mediations are removed, other are added, changing the socio-technical networks of the data. I would like to emphasize three politics of reattachment of data to new users: the consolidation, the homogenization and the articulation.

Consolidation

Produced to meet a specific use, the dissociation of the ties between the producer and the user of data endangers the solidity of open data. While it is impossible to be sure that the modalities of production meet the needs of the secondary users, data are threatened with deliquescence (Didier

[6] Source: https://libertic.wordpress.com/2013/09/24/vers-la-fin-du-baby-blues-de-lopen-data (retrieved May 14, 2016)

2009). For instance, produced for the traffic regulation, the public database describing the road networks cannot be used to calculate routes as Jacques, a data re-user, explained:

These data are inoperable to make graph transversal, that is to say to move from a point to another one, because there are no structural nodes, which allow to say "From here to there, we can go, from there to here, we cannot.

To be used in another social world while preserving their solidity, data must become boundary-objects (Star and Griesemer 1989). The open data as boundary-object need to be both adaptable to be used in various context and robust enough to maintain a common representation of the urban space between the actors. Data have to obtain two crucial properties: an interpretive flexibility and a common infrastructure between these social worlds (Trompette and Vinck 2009). These two characteristics are not inherent to the data but depends on the situation where they are used.

Before all secondary uses, re-users realize two operations: "sourcing" and "cleaning" the data. The first one consists of the identification, the understanding and the estimation of the liability of the data, to be sure it will fill the re-user's needs. The second one represents all the preliminary actions on the data before integrating it in a new informational environment. The two operations strengthen the consolidation of open data by estimating their interpretive flexibility, that is to say to check they can meet a secondary use without lose their initial meaning. However, they are not sufficient to allow the open data to become a boundary-object. A shared infrastructure between the producer and the re-user is required. Open data can easily cross organizational borders if it fills with the particular conventions of a professional field. If the traffic data are published in a standard format, it will be easily used by a traffic specialist and integrated in his own information system. For instance, this dataset was used by several companies specialized in traffic information: to publish real-time information in mobile apps or to make traffic prediction. As a result, open data as boundary-object allow the coordination of various actors through a common representation of the urban space defined by local authorities.

Homogenization

The homogenization is the production of a new aggregate from heterogeneous databases. The open data is a source of information among others to produce a new data which will standardize various representations of the urban space. For instance, Here Maps is a company providing mapping data to navigation services. The construction of these maps rests on various sources of information. Open data are used exclusively to update the initial database. To be associated to the Here's database, open data must respect precise norms established by the company in order to ensure a high degree of quality. Realized by local workers, these operations of data qualification and integration are largely invisible. However, they are crucial to smooth the numerous frictions which are inherent to the establishment of a relationship between informational infrastructures.

The construction of this homogenized database requires an equivalence convention in order to obtain a standardized representation of road networks all over the world. Unlike national statistical system, the definition of these conventions is no longer the sole privilege of the State or public actors. Private actors, like Here Maps, establish their own equivalence conventions, exposing public bodies to a loss of control over their public policies. Traffic regulation policies represent a good example of this risk. In this domain, public information services are in competition with private GPS services. The latter's road databases are based on an equivalence convention which differs from the hierarchy of roads defined by local transportation authorities. This difference of representation is not neutral: it is a prescriptive force to drivers through routes offered by GPS services. This is particularly apparent in case of congestion when the traffic is relocated to roads public authorities considered not suitable (minor road, etc.). The hierarchy of roads set by public authorities are no longer the convention, which reduces its ability to regulate the traffic regulation policy.

Articulation

The articulation is the third modality of open data reuse. It is characterized by the linking between various data through a common attribute. The heterogeneity of each data is preserved. For instance, the project Optimod, an intelligent transport system developed by the Great Authority of Lyon, whose aim is to gather, articulate and analyze data from all modes of transportation to offer multimodal information services. The differences of structuration of each data make impossible their homogenization in a common database. The challenge is to preserve the data inheritance by linking the datasets without change the way they are produced. An articulation work (Strauss 1988) is thus necessary using a common denominator. In the project Optimod, a geographic frame of reference, describing all the road network, was produced to allow the relationship between databases that were incompatible.

The outcome of this data articulation work is a new representation of the urban space. While transportation data represented the transportation network as a whole, data articulation offers a representation of all available transport modes according to the user's location.

From a representation of flow of vehicles to a specific representation for each traveler.

As a result, the target of policy moves from transportation networks to each individual. Transportation is not any more managed through the representation of flux of vehicles in a road network, but it is governed through individual travelers to which a singularized representation is offered. The articulation of data does not yield generalized representation, but it allows particularization. Using articulated data, it is no longer the "we" which is governed, but each individual that becomes governable.

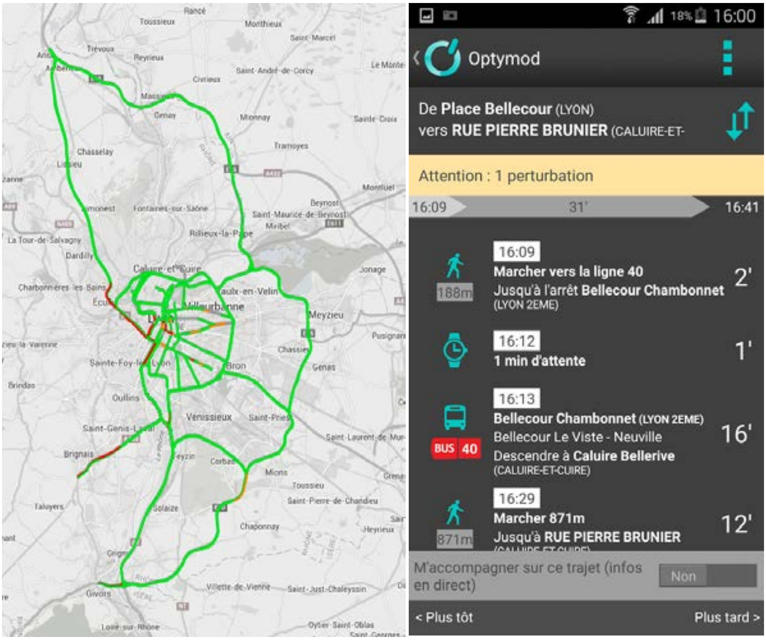

Figure 1 – From a representation of flow of vehicles to a specific representation for each traveler.

Conclusion

Drawing on empirical analysis of an open data policy, I have sought to contribute to the information infrastructure studies (Bowker et al. 2010; Edwards et al. 2009), by pointing out an inherent tension between attachment and detachment when making data circulate. Using the concepts of attachment and detachment to analyze the circulation of data highlights the sociotechnical network of a data and its necessary reconfiguration when data cross organizational borders. This aspect is crucial at the age of *big data* which place secondary uses of data at its core. Moreover, the attachment's framework focuses on the attachments of data, but also on how the data itself attached (Gomart and Hennion 1999). Following the example of traffic data, I sought to underscore the joint redefinition of the data, the representation of the urban space and the institution acting on it. Moving from one social world to another one, the open data obtain new characteristics. This evolution of data changes the representation of the urban space, and, *in fine*, affects public policies.

- The consolidated data is a boundary-object allowing the coordination of various actors through a common representation of the urban space. The consolidation gives the producer new regulation opportunities by gathering these actors around his data.
- The homogenized data offers an alternative representation of urban space by the establishment of a new equivalence convention. The producer loses his control of the representation of the city which is a risk in case of conflict between these heterogeneous points of view.
- The articulated data gathers a diversity of points of view on a same object. In this way, it makes visible the singularity of each of these entities and makes possible their individual government.

This attachment/detachment framework opens new perspectives to analyze the reconfiguration of urban government in the age of information liberalism.

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Transparency in the Rupture? Open Data and the Datafication of Society

Rolien Hoyng

According to the handbook by the non-profit organization Open Knowledge International, Open Data's definition centers on the availability of (digital) datasets "at no more than a reasonable reproduction cost," "in a convenient and modifiable form," and regardless of the fields of endeavor where they are applied.[7] In this essay, I am interested in Open Data's coalescing with larger processes of datafication and the contradictions stemming from the combination of a discourse of transparency with the expedience of data for capitalism and algorithmic governance in the so-called smart city. That is to say, a profound ambiguity exists regarding what Open Data is all about. On the one hand, there is a promise for transparency, oversight, and mastery, building on Enlightenment epistemologies and notions of agency. Yet, on the other hand, we witness compounding datafication, namely the rendering into data of social processes and everyday life by means of (self)tracking in order to govern populations, markets, and cities (Cukier and Mayer-Schoenberger 2013). Despite its promotional discourse, Open Data does not reveal or open up a terrain of "pure" transparency and unmediated visibility. Instead, Open Data (re)produces regimes of visibility, enacting particular modes and distributions of perception and cognition (Birchall 2015; Flyverbom et al. 2016; Halpern 2014). In this essay, I address the implications of so-called 'smart', data-driven

[7] See http://opendatahandbook.org/guide/en/what-is-open-data/

urbanism for citizenship.

Yet rather than associating the smart city's datafication with all-encompassing oversight and efficient control, I emphasize the messy and speculative character of data-driven applications, the productive role of errors and failure, and the elicitation of socio-technical emergence in smart urbanism. I argue that the critical import of 'transparency' needs to be reassessed in relation to these dynamics. If data activism should not be oriented onto 'opening up' the black-boxed smart city in order to restore transparency, what might it target instead?

Open Data draws from histories that invigorate the value of transparency and reinforce supposed relations between seeing, knowing, and acting. Bratich (2016, 178) raises the question of what the Enlightenment era would be "without a will to transparency?" He (178) continues: "[H]ow would modern communication persist without a similar desire—for openness, for clear channels, for a world without obscurity?" Transparency is connected to the dream of an entirely visible society, in which there is no "dark" corner remaining. Data and information play a key role in rendering society governable, but also governors accountable (Ananny and Crawford 2016, 2-3; Foucault 1979, 195-228). Accordingly, Open Data practices abide by a regime of visibility centered on "representation." Data function as evidence for what exists "out there" and possess a referential capacity (Halpern 2014, 46-51). Ordering data (through capturing, structuring, aggregating, and visualizing) forms part and parcel of ordering society as well as eradicating irrationalities, inefficiencies, and corruption. Especially the release of public service data carries with it the promise of rendering governance more efficient and holding governments accountable. For instance, Open Data initiatives can publish datasets on air or beach water quality that enable others to build apps or otherwise inform people about when to go out or swim. But with the data at hand, people could also find ways to track environmental quality over time in different areas in order to hold governors accountable for the state of affairs. Other datasets pertaining to government operations may assist in analyzing and visualizing politicians' voting behaviors or governments' budget expenditures.

Yet Open Data also supports datafication and the algorithmic governance of targeted populations and markets. As many critics of the smart city have argued, datafication is concomitant with the expansion of society's technological cognitive nonconscious (Hayles 2014), advancing covert forms of social sorting, profiling, modulation, and control to which populations are subjected (Deleuze 1992; Lyon 2001). Datafication draws from histories of cybernetics, which have reformulated cognition or intelligence in terms of rationality rather than reason. Cybernetics render human agency more or less intrinsic to preset computational rules, whereby small decisions are made in decentralized fashion that may be rational in the sense that they follow certain logics but that do not live up to the ideal of reason of a sovereign human subject standing apart from its environment (Halpern 2014, 173-191). When consumer-citizens in the smart city engage with the interfaces of data-driven governance, they are often merely interpellated as data operators, who input data and act upon the feedback (Gabrys 2014). Interactivity is enabled as much as constrained by the design and protocols of the interface and often does not provide oversight of larger processes beyond self-tracking, let alone capacity for sovereign decision-making. As discussed in Young's contribution (in this issue), corporations are primary users of public datasets, as they combine Open Data with, for instance, social media data and data gained by tracking eye and body movements. Whereas this enables corporations to segment markets with increased granularity and predict consumers' behaviors and proclivities, whatever data their activities generate remain proprietary, as do the algorithmic applications deployed to process data. At stake is the paradox that Open Data despite its allusions to open access and transparency may be implicated in the advancement of digital enclosure (Andrejevic 2007) and empower corporate actors rather than citizens and the public at large.

Yet any account that portrays the datafied smart city only in terms of efficient control misses the following: data are often much less precise and all-encompassing than generally presumed, and algorithmic governance much more speculative, tentative, and prone to failure than expected. It may be the "messy" qualities of smart urbanism, rather than the ability to conclusively surveil and order, that deserve our analytical and critical attention. For instance, security tools in the smart city correlate heterogeneous datasets in order to calculate probability and risk. Yet risk-calculating derivatives do not draw conclusions on the basis of precise data with indisputable referential qualities. Instead, such derivatives infer and project on the basis of "uncertain and indifferent relationalities of missing elements" (Amoore 2011, 38). Rather than truthful representation, "[w]hat matters instead is the capacity to act in the face of uncertainty, to render data actionable" (Amoore 2011, 29). Not only are mistakes – false hits in the context of security – they also do not form systemic weaknesses. As long as mistakes provide feedback that helps the system evolve, they are productive: "The false hits of multiple security interventions that prove negative can never be errors in the terms of the derivative, for they too are folded back into association" (Amoore 2011, 32). Similarly, reviewing the development of the smart city of Songdo in Korea, Halpern et al. (2013) discuss test-bed urbanism as a way of experimenting with the management of urban space and life by means of extensive tracking. This extensive tracking does not imply the production of order through knowledge and surveillance. Instead, Halpern et al. (2013, 295) refer to smart city urbanism as a "new form of administration that lacks norms, frequency distributions, and the statistical apparatus of older demographic, state, and economic thinking in the name of a new epistemology of infinity, nonnormativity, and speculation." Smart urbanism operates through the uncertainties of speculation, trial, and emergence. Datafication here stands in the service of the production of value by means of innovation, for which the instance of failure is a driver rather than an obstacle, as long as its data result in the "next" thing. In this context, constant testing and versioning replaces decisive conceptualization of failure and loss.

The messy character of algorithmic governance somehow corresponds to smart urbanism's organizational models. Whereas the tactical, speculative interventions of data-driven governance undermine disciplinary techniques of statecraft, state authority (at least to some degree) relinquishes centralized organization, overview, and control. Though such narratives still demand critical engagement, smart urbanism evokes scenarios according to which cognition is not centralized and rational (as is state authority); instead it takes its cues from swarms, insect colonies, and chaotic systems that inform models for self-organization (Halpern et al. 2013). In this present issue, Blok and Minor's discussion of governance practices such as 'living laboratories' and participatory design provides an empirical account of the extent to which smart city governance seeks to harness a degree of socio-technical contingency, rather than contain it, in order to multiply the effects of data across the smart-city environment. Accordingly, Thrift (2014, 6) proposes to see sentient cities as "spaces of ramification as different kinds of edge structure" and "as refuges that encourage experiment, tinkering and other adaptive practices" that offer "new ways to produce chaos out of order […]."

If data tracking in the smart city has to do with tactical intervention and tapping socio-technical emergence in environments that collide failure and success, where does this leave the value of transparency? Should critical analysis and data activism revolve around regaining transparency vis-a-vis the black-boxed smart city? The role of data in the production of order on the basis of reason – in other words, data as part of the coupling of power/knowledge – is challenged. But so is the value of transparency in the service of accountability in that the latter might not be able to tackle the open-ended quality of smart systems and processes of socio-technical emergence that exploit failure and are enabled by incompleteness. Discussing algorithmic systems operative in areas of public governance ranging from transport to healthcare and policing, Ananny and Crawford (2016, 9-10) argue that even system designers themselves might not be able to provide a clear picture of complex and dynamically changing, adaptive systems. But more, the demand to "open up" the smart city's black boxes and see any systems does not yet account for less immediate and more complex socio-technical ramifications and (unintended) emergences.

Alternatively, engaged struggle could target the distribution of perception and cognition and the potential for socio-technical emergence itself, which is one way to interpret data activism and hacktivism. Coté (2014) has suggested that data activism might revolve around the dualism of data mobility and motility. The former refers to the contained movement of data that "primarily augments the profitable growth of the business of BSD [Big Social Data] and new forms of digital state surveillance" (123). Those actors however "loathe autonomous data motility," which "signals a possible route for the progressive becoming of a new data commons" (124, 140).

Accordingly, data activism includes scraping, rescuing, and "freeing" data. In such instances, data are not simply accessible and "open" but seized and motile in order to be processed in various ways. To the extent that activism preys on infrastructural "cracks" and systematic weaknesses in order to seize and "free" data, it is not smart urbanism's success and failure (as in test-bed urbanism) that start to merge but resistance and failure.

To sum up, regardless of the fact that smart urbanism is stimulated by actual governments – utilizing the public service Open Data these governments provide – datafication unfolds at the expense of centralized state power and statecraft. It implies an increase of proprietary data relative to public data as a result of smart urbanism undertaken by the private sector, even though states and especially their security and intelligence units can demand access to this data, too (Taylor and Broeders 2015; Van Dijck 2014, 203). The ensuing technological cognitive nonconscious (Hayles 2014) is however messier and less controllable than often assumed. Smart urbanism challenges disciplinary modes of statecraft intended to produce order by means of transparent oversight, notwithstanding the fact that the very linkage between data, transparency, and order undergirds the promise of fortified governance efficiency and accountability in Open Data discourses. The encounter between Open Data and datafication as the de facto un-mappable expansion of society's technological nonconscious generates contradictions and concocts a field of struggle. "Seizing" data and rendering it motile could form a tactic of resistance intended on releasing data in more radical ways than Open Data initiatives generally do. Critical questions are: what does it take for Open Data to become a site and medium for the expression of antagonistic struggles, in ways that belie Open Data's semblance of neutrality rendered through claims to indiscriminately support all uses of open datasets? For instance, in what ways could tactical interventions exploit Open Data's regimes of visibility in order to generate alternative modes and distributions of perception and cognition? And, how would such interventions radicalize the construction of "openness" in Open Data? But also, data activism itself requires more critical attention. Is it necessary to actually distinguish between failure and resistance and hence to further qualify those seizures and motilities that would be able to counter the disempowerment of variably-positioned bodies and different subjectivities in the smart city? Especially, if smart urbanism already is characterized by a degree of chaos and decentralization, in what ways could the seizures and motilities inflicted by data activism disrupt the ongoing disruptions incurred by smart urbanism?

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The ecologies of open data labor. A case study of the coproduction of an open geographical data base

Clément Marquet

This contribution concerns the collaboration between Transilien, a public transport operator on the region Île-de-France[8] and the association Open Street Map (OSM) France. OSM is an open crowdsourced geographical data base, mainly produced by volunteers (Goodchild 2007). The partnership aims at asking the OSM volunteers to map the accessibility for the disabled equipments in 90 of the 380 railway stations composing Transilien's network. The mapping has to be done during the summer 2013, between June and September. Indeed, as part of Transilien open data policy, these geographical data has to be valued during a hackathon[9] in November, in order to test how useful they can be for software developers.

However, in September 2013, Vincent, Transilien's chief of project discovers that only half of the mapping has been done. The volunteers did not respond to the call made by the association. With the spokesperson and the president of OSM France, Vincent has to contribute to the mapping, mainly during his free time. Though the mobilization of the volunteers is seen as a failure, the geographical data are widely used by the participants during the hackathon and Transilien decides to keep mapping its station on OSM. But the mapping can't rely anymore on the volunteers, Transilien considers paying people for that. As we will see, mapping is a tedious activity, and we will wonder how this tiresome and volunteered practice is turned into a paid work, within the open data ideology of "doing more with less".

Having to produce the data one wants to open is a typical situation in open data projects, as Jérôme Denis and Samuel Goëta have shown (Goëta 2016; Denis and Goëta 2017). Data rarely exist in the format desired and opening data necessitates a lot of work of identification, extraction, cleaning, etc. On the same trend, Antoine Courmont (2015) states that opening one's data implies reframing one's information infrastructure (Star and Ruhdeler 1996) to take into account cleaning processes and alternative uses of data by external actors.

Collaboration between Transilien and OSM implies producing an "open" data base in two dimensions: first, one that can be reused by software developers, second, one that can be completed by anyone (the only condition is to be registered in OSM). Wondering how the OSM data platform becomes a boundary-object (Star and Griesemer 1989) between OSM

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[8] Transilien is a subsidiary company of Société Nationale des Chemins de Fer (SNCF), the main railway transport company in France.

[9] Hackathons consist of generally 48-hours software developers contests.

community and a public transport operator, we will pay a close attention to the organizational and labor transformations: what forms of data labor are invented by Transilien? What kind of competences are recognized in geographical mapping? How does those transformations relate to the OSM community?

1/ Mapping practice

To understand the lack of mobilization of the volunteers, it is important to have a clearer idea of what kind of an activity mapping is. OSM is generally presented as a platform where everyone, once registered, should be able to contribute. To take part in drawing the map, one does not need expensive tools: the basic process is to print the area to be mapped on "walking papers" (figure 2) and start listing the items lacking in the public space, whether those items would be buildings and roads, or traffic lights, trees and pedestrian crossings. To help her in her task, one could use a GPS or smartphone, to record geographical position and take pictures of the area.

Figure 2 – Walking paper. Source: http://wiki.openstreetmap.org/wiki/File-:Surveying_with_walking_papers.jpg (CC-BY-SA 2.0+).

Once the outdoor mapping is done, the contributor has to turn it into data, that is "machine readable" information in the right format. To do so, the volunteer has a various set of free software to use, more or less user friendly, according to his level of expertise. User has to draw dots, lines, polygons, and tag them using information resources already in the software or coordination tools available online.

Thus, mapping starts with outdoor activity, or indoor, concerning the stations. However, having to go in each station on the railway network is not an appealing perspective for the volunteers. Furthermore, the specific accessibility equipment is difficult to be seen for one who isn't used to seeing it. Last and not least, mapping is also presented as a meticulous and tedious activity. OSM volunteers describe themselves as "the ants" and Gael does not hesitate to qualify as "fucking boring" the moments when one "is counting steps under the rain" or adding data "until your hands hurt". But, he adds, "at the end it's perfect, and that is what makes the beauty of it."

2/ Paying the mappers: from dirty work to external expertise

Organizing the production of data in OSM is not a linear process for Transilien, but rather a trial and error process. From October 2014 to June 2016, Transilien uses three methods to produce data about its network.

A/ Mapping as a dirty work

To produce a large amount of data on the 290 stations left in a short period of time, Transilien hires students. Sixteen students are trained to OSM software and field mapping by OSM France leaders. They have roughly access to the same material and information as OSM contributors: specification note, walking papers, camera and smartphone GPS. The kind of contract linking the student to the firm is quite loose. As a precarious job, students are paid "at the station". Some will never go through all the stations they should do, others will complaint that the data they harvested have been changed or rejected by contributors. According to Vincent, this experience was tough because of the problems of skills and the lack of coordination.

Here, mapping appears to be a dirty work (Hughes 1962). If we recall the tedious process described by Gael, we understand that this process is delegated by Transilien to students. As they do not see the beauty of it and as the added value to their formation is quite slim, recognition is hard to be found. Their coordinator clearly states that this is far from being it is main project at the time.

B/ Internalizing competences through an OSM contributor

In 2015, a change is made in both the managing and the strategy of the mapping. For personal reasons, Vincent has to stop working in Transilien, and he is temporarily replaced by an OSM contributor, Florian. He explains that the work of the students was too messy: the tags weren't coherent enough, the mapping was not accurate. He doesn't blame them, as they were nearly starting from blank slate. However, most of their work is finally erased and Florian reorganizes the mapping procedure. Hence, he draws map from his office, using architects' plans, rather than going on the field. Once he has drawn the 379 stations, he goes checking what has changed, what could be added or deleted. However, despite of his efforts, 8 stations resist to the mapping. The most complex, multilevel stations are far too difficult to be mapped from the only basis of architect plans, even for an experienced mapper.

C/ High expertise mapmaking: OSM contributors as service providers

Through Florian, Transilien contacts a geomatics company named Cartocité. This agency is composed by three regular OSM contributors specialized in hardware and software development, and in geomatics. It is the first time the agency signs a contract to realize OSM mapping. Such a structure was necessary in particular because of confidentiality contracts. Indeed, mapping the stations gives the agency access to the architectural layouts of the station, as non public areas should not be mapped in OSM. When interviewed Antoine sees this as a privilege, in his point of view, many OSM mappers would have been delighted to be authorized to map a station through architects layouts, without even being paid for that. Once they have the layouts, Cartocité employees enter in a three months process, involving software and hardware development (a four camera pod to take 360° pictures), plus the advanced knowledge of geomatics and OSM software.

The first steps of the production of railway stations open data reminds classic information gathering across history, from the birth of statistic polling, which consisted in hiring unemployed people (Didier 2009), to recent practices of inquiries which also rely on law qualified jobs (Caveng 2012). Data harvesting is considered by Transilien as a dirty work (Hughes 1962), that could be done with little investment. However, contrary to opinion polls, the geographic data expected by Transilien needs high accuracy. Furthermore, mapping is not considered as a dirty work for everybody. As a relational notion, what is dirty and boring to some is not for others: most of OSM contributors see mapping activity as a – tedious – leisure (Dufeal et al. 2016).

Thus, Transilien takes into account complexity of data production as an issue of competences and labor perception, and hires OSM contributors and experts accordingly. However, by doing so, the leisure becomes a labor, which questions Cartocite' employees. This episode gives us an insight regarding the tensions coming with open data transformations: administrations tend to expect producing value with low investments, considering data as a simple asset, with few considerations of the work that must be done to make it “open”. Taking this work into consideration needs, as we will see, to rethink the ecology of data labor.

3/ Maintaining the data: coordinating experts, agents and the crowd.

However, having turned stations into data isn’t enough to have an open data platform. Opening data aims at the circulation of data, which means that many operations are required to let the data flow (Courmont this issue). Data have to be updated to follow up the transformation of the physical spaces. Other forms of data labor and organizational transformations are needed. To deal with data maintenance, Transilien divides the issue in two dimensions, both reframing data labor: updating and surveillance.

A/ An app to update the map

To have data up to date, and considering the failure of relying on the only OSM regular contributors to do so, Florian have the idea to develop a smartphone app. The aim of the app is to simplify the contribution process on the station. Anyone could add data in a few seconds, avoiding the more or less user-friendly editing software that are repulsive to the newcomers. In June 2017, a prototype is delivered. According to the management, it should be used by the travelers but also by the agents.

Thus, by doing this application, Transilien and OSM contributor Florian are opening another potential transformation in the OSM model of data production. By simplifying the addition of data, the app could move the model of production from a community level, in which volunteered are getting more and more entangled with professionals, to a crowd model, which allows a widening of the contributors but also lightens the links between them (Haythornwaite 2009).

B/ Surveilling data

With the open data base, the company faces new risks such as malevolence, errors or “tag wars”, which corresponds to disagreement between contributors regarding how to tag an item (Mooney 2011). The company could not accept this kind of volatility if services rely on the open data base. To overcome this situation, Transilien hires Cartocité. The agency has to develop software to monitor data activity on the stations. This makes the agency accountable enterprise for the station’s data and stabilizes the role of the company as an “OSM professional”.

Many contributors developed tools in order have a watch on specific parts or items on the map and insure quality of data (Goodchild and Li 2012). As it was the case with the intensification of data production on complex station in the first part, we assist at a “formalization and an industrialization of practices that already existed” - but not at as a paid service.

C/ New roles for the agents

At the intersection of both the surveillance and the updating program, we can find transformations in the mundane work of Transilien agents. Indeed, Cartocité's surveillance process is to send the dubious data to Transilien employee who then send the data to the head of the station, who asks the agents to check whether the modified items are corresponding to the reality or not. Furthermore, the updating app, Mapmagare, has a version dedicated to agents. Thus, either checking what has been modified, or registering fresh transformations, agents become in charge of the stations data.

This second moment in the organization of the open data infrastructure let us see the production of an ecology of data maintenance articulating external companies, Transilien managers agents and a hypothetical crowd. The issue is not anymore about the harvesting of data but concerns the management of the "data lifecycle" across time, which demands more coordination, mostly assumed by the production of new software: monitoring software, for Cartocité, mapping software, for the agents and the crowd.

The transformation in Transilien organization also have effects in the OSM community, as the OSM France association is now wondering how to deal with the professionalization of the contributors. Should the association get paid workers to be able to respond to demands such as Transilien's one? In June 2017, the bureau of OSM France have decided that its role would be to give visibility on their website to the self declared "OSM professional", but that they will not recommend one or another not to create inequalities amongst them.

Conclusions

By focusing on the collaboration between various kinds of actors to produce a geographical data set in an open data base, this commentary gives an insight of the situated inventions of open data labor and of the organizational transformation that goes with this invention.

Though the open data platform is shared between Transilien and OSM, Transilien is taking the most active part in the production and the maintenance of the data set. The direct contribution of business practices in the open data base could have been seen as a problem, like it is in many open source communities (Demaziere et al. 2009). According to the various actors implied in the process (Cartocité, OSM France association, Transilien, and a few OSM contributors), the OSM basic rules of contribution and data license provide a framework to allow the entanglements of public and private interest in the data production and maintenance.

Along this common goal we can see many attempts from Transilien to fine a suited coordination of actors to map its station. Indeed, though Transilien accepts to play by OSM rules in the production of data, the company also tried to make this production as cheap as possible. Paying a close attention to the production and the maintenance of the data reveals the variety of the forms of data labor experimented in the collaboration along with the coordination of various models of data maintenance, articulating OSM community with a wider crowd, agents mundane work and a surveillance company.

Finally, we can see how open data platforms and the original public private partnerships made around them (Young this issue) contribute to blur the boundaries of what counts as work (Strauss and Star 1999) in the liberal information society.

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Neo-Environmental Sensing: Ontological approaches to public data

Christian Nold

Introduction

This text offers a preliminary scoping of what I call ‘neo-environmental’ sensing. In the last decade there has been a radical change in environmental sensing, with hardware becoming cheaper and involving the public in data gathering. ‘Neo-environmental’ sensing takes place outside of governmentally mandated monitoring in the context of ‘participatory sensing’, ‘citizen science’ and ‘smart cities’ and uses networked technologies. The most commonly cited example is the Safecast radiation monitoring network that emerged in response to the Fukushima nuclear disaster (Safecast 2011). The hardware built by volunteers provided vital data for the public while the governmental response was criticised. Since this incident, there has been an enormous growth in low-cost environmental sensor systems built by hobbyists, entrepreneurs and research projects. These sensing devices are often crowdfunded via platforms such as Kickstarter and Indiegogo with the intention that people install them in their homes or carry them with them every day. The term ‘neo-environmental’ sensing is a reference to the ‘neogeography’ movement (Turner 2006) that emerged in 2006 and was often attributed to the newfound public access to global positioning systems (GPS) and Web 2.0 technologies. Neogeography brought a new range of people to develop and use geographical mapping systems in ways that did not follow established protocols: "rather than making claims on scientific standards, methodologies of Neogeography tend towards the intuitive, expressive, personal, absurd, and/or/artistic, but may just be idiosyncratic applications of 'real' geographic techniques" (Eisnor 2006). The fact that neogeography did things 'differently' led to a range of epistemic and ontological tensions about how mapping practices can create truths (Warf and Sui 2010). In practice this often emerges as conflicts around data quality and power dynamics with volunteers, as illustrated in the text by Marquet (this issue). My paper involves a preliminary sketch of 'neo-environmental' sensing to identify how it differs from existing environmental monitoring that is based on specialised, calibrated sensor hardware. Some observers are already starting to question the impact of this new sensing paradigm (Kumar et al. 2015). My paper suggests 'neo-environmental' sensing presents a challenge to pollution-affected communities but also offers potential for ontological translation and contestation. In addition it creates a new role for academic researchers to help communities translate 'smart' data into matters of concern. The paper is based on my PhD research where I analysed four 'neo-environmental' devices over a period of years from design, usage and output (Nold 2017).

Environmental sensing via publicity

Institutional sensing of air and noise pollution involves large stationary hardware that costs tens of thousands of euros and is focused on long-term trends and regulatory standards. Another class of portable devices costs thousands of euros, and is used in response to specific pollution incidents. The cost and complexity of this hardware puts them out of the reach of pollution-affected communities. However, 'neo-environmental' sensing devices use 'free' inbuilt smartphone sensors or hardware that only costs hundreds of euros. The tradeoff for this accessibility is their limited capabilities that cannot differentiate pollutants, are often uncalibrated and are affected by temperature and humidity. Yet, 'neo-environmental' sensing devices offer very sophisticated networking capabilities, data repositories and APIs. The focus is not on the individual measurement instrument but on creating large scale sensing networks and visualisations. These visualisations are often real-time and graphically more sophisticated than governmental webservices. The goal is quantity and interoperability of data following concepts such as 'smart cities' (Batty 2012) and an 'internet of things' (Ashton 2009). Crucially, 'neo-environmental' sensing devices tend to be accompanied by a vast range of buzzwords and publicity. The common narrative is that sensing devices are 'smart' technologies that bring disruptive potential. A frequent claim is that there are more mobile phones than people on earth (Alfonso et al. 2015) and that this will create a global sensing network where the

> planet earth will don an electronic skin. [...] It consists of millions of embedded electronic pollution detectors, cameras, microphones [...] These will probe and monitor cities and endangered species, the atmosphere, our ships (Gross 1999, par. 2).

The argument is that digital networked sensing will lead to new ecological management as illustrated by articles such as *How Two Billion Smartphone Users Can Save Species!* (Preece 2017). Smart technologies allow the cost and labour of environmental sensing to be passed onto the public (Silvertown 2009). Some suggest these networked sensing platforms will become alternatives to governmental institutions (Townsend et al. 2010) and generate new technological citizenship (Kera et al. 2013). Kresin (2013, par. 3.) argues,

> we know how to measure ourselves and our environment, to visualise and analyse the data, to come to conclusions and take action. [...] We are ready. But, as yet, our government is not.

Other researchers suggest that gathering environmental data will make participants more supportive of technological and scientific progress (Bonney et al. 2009) and shape environmentally beneficial behaviour (Maisonneuve et al. 2010; EveryAware 2011). In this framing, environmental sensing devices are no longer just sensors of external pollutants but become persuasion actuators that attempt to transform the user of the sensing device. In contrast, older, analog sensing devices such as diffusion tubes are hardly mentioned within the participatory sensing literature. Diffusion tubes have been used in the UK since 1976 (AEA Energy and Environment 2008) and consist of small plastic containers coated with chemical reagent that after exposure are sent to a certified laboratory. They are cheap and accurate ways of measuring air pollution, yet are not part of 'neo-environmental' sensing, since they do not contribute to global digital networks and mediagenic publicity.

These narratives highlight that 'neo-environmental' sensing is less concerned with material pollutants and health impacts and instead re-articulates the environment as data networks and mass involvement. I suggest that 'neo-environmental' sensing should be seen as more 'expansive' than traditional environmental monitoring. It involves a range of 'big words' (Bos et al. 2014) and 'buzzwords' (Bensaude-Vincent 2014, 250) that function to "create peaceful collectives of people with competing agendas. They act as a soft power attracting and enrolling people, thus preventing violence". While these narratives have been successful in bringing together EU policymakers, academia, commercial entities and hobbyists, others such as pollution-affected communities have not been part of these narratives. What is missing in the literature, and which this paper tries to remedy, is an acknowledgment that 'neo-environmental' sensing represents a challenge to existing public data practices.

Devices that shift subject and object

This paper provides a brief snapshot of how four 'neo-environmental' sensing devices impacted participants and engaged communities. In general, there was an ambiguity of what exactly the devices were sensing. Remarkably, all the devices started off sensing one entity and then shifted towards other phenomena. One device started off promising to sense pollution and offered radical political change, while at other times it was framed merely as a community of concerned people. Another device gave little detail about its hardware sensors but claimed to transform the public into smart citizens; while yet another device abandoned air pollution to focus on measuring the user's mental awareness and behaviour. Often, users themselves became framed as the main subject of sensing, rather than external pollutants. Crucially, the ambiguity of what was being sensed existed also at a material level, where the devices were poor at differentiating phenomena and had sensors added over their lifetime. Two devices had interface sliders added to monitor and measure the behaviour of the users. Pollution data was often presented as raw values that users could not compare to official datasets. The devices often left the participants confused and frustrated and health impacts could not be meaningfully discussed. Nevertheless, the devices were all well funded, attracted many participants and were cited as good-practice exemplars within academic literature, EU policy reports and the mainstream media.

How was this possible? My suggestion is that 'neo-environmental' sensing does not function as an epistemic knowledge practice. The classic model of environmental sensing is premised on what Latour calls scientific 'chains of reference' (Latour 1999). These allow the backward tracing from a scientific report to the dataset and finally to the pollutant phenomena in the world. In this chain, sensing devices are meant to act simply as 'intermediary objects' that allow the progressive abstraction of the world into a scientific text or institutional report. Yet in 'neo-environmental' sensing, devices are not intermediaries and do not offer chains of reference. Instead they function as assemblages that combine a variety of different agendas. I suggest we should think of them as "patterned teleological arrangements" (Law and Ruppert 2013) to highlight the way they act as concentrations of agendas. This conceptualisation allows us to see how the devices fused together hardware with layers of rhetoric, visualisations and participants. By being ambiguous about 'what was being sensed', the devices could be detached from sensing material things such as pollution gases or sound vibration to become something more expansive and expressive. The device organisers often described the devices as 'beacons', 'nodes', 'bridges' and 'vehicles' towards something else. This ambiguity allowed the devices to articulate buzzwords of networked environments encompassing radicalism, smart citizenship and behaviour change. The result is that 'neo-environmental' sensing became much 'bigger' and more 'innovative' than traditional environmental sensing and able to generate more publicity and enrol more participants. In the framing as public engagement and digital network construction, 'neo-environmental' sensing devices became successful and won international awards even if they created a radically altered relationship towards the environment.

Translating 'smart' data into matters of concern

Yet this 'neo-environmental' approach caused problems for participants who had active health concerns or lived in pollutant-affected areas. Many of the participants were not aware of the ambiguous nature of the sensing devices and were often confused and frustrated and did not know what to do with the generated data. Traditionally political actors outside of science have often appropriated the credentialed 'intermediary objects' of science for their own purposes to create their own chains of reference in order to legitimate their environmental concerns. A well-documented example is the bucket brigades (Overdevest and Mayer 2007) that used containers to collect air samples, to be sent to a certified laboratory for analysis. In this way, legitimacy is embedded within the scientific instrument that is then 'borrowed' by a pressure group to make its localised argument. Kullenberg (2015, 67) suggests,

> by turning to scientific methods in their political struggles, citizen scientists are able to 'short-circuit' the conventional modes of seeking political representation and use reference as a mediator in re-presenting the state of affairs that have come under controversy.

Similarly, Carton and Ache (2017) describe the potential of low-cost environmental sensing as opening a dialog with governments to strengthening the negotiating position of communities as 'information power'. Yet in my studies of organised deployments with 'neo-environmental' devices, groups that tried to use an epistemic logic of 'information power' could not make use of the data generated and led to the removal of the data from existing datasets. I argue, that 'neo-environmental' sensing does not support the borrowing of epistemic legitimacy, but instead requires a fundamentally different - ontological approach to environmental sensing. In this approach, sensing devices are used to deliberately enact multiple 'realities' as in Annemarie Mol's notion of ontology, where

> ontology is not given in the order of things, but that, instead, ontologies are brought into being, sustained, or allowed to wither away in common, day-to-day, sociomaterial practices (Mol 2002, 6).

This ontological approach is best illustrated via a small case study of a 'neo-environmental' sensing device called WideNoise (EveryAware 2012). This smartphone noise-sensing app was originally created by a company as a technical demonstration of smart cities and internet of things and then later used by an academic research consortium. Crucially the app was uncalibrated and produced poor sound level measurements. Nevertheless, it proofed to be surprisingly useful when used in relation to the contested issue of Heathrow airport expansion in London. A number of local actors managed to ontologically reconfigure the app to 'sense' a variety of entities that were relevant for the local controversy. Heathrow airport is the world's third largest, and there are plans to expand it with an additional runway that will dramatically increase local air and noise pollution. The issue is a clash between different realities of environmental pollution as articulated and practiced by local residents, pressure groups and the commercial airport and politicians. In the context of a noise monitoring campaign jointly coordinated by a university and a pressure group, local residents and a council managed to re-purpose the app to enact new environmental ontologies and create connections towards institutional decision making on the runway expansion. The residents used the app to selectively measure the loudest planes that they found the most annoying. Their goal was to find an alternative to the current noise metrics that statistically average the measurement of noise events and thus underrepresent the sensorial shock of quick and loud over-flights. Crucially, the participants did not see the selective measurement of loud flights as manipulation of data but as adopting a rigorous experiential protocol. This could be clearly seen in the way the participants took care to be selective and avoid measuring non-aircraft noise. The residents were not trying to create exaggerated 'fake' data but were highlighting the 'real' high measurements that were occurring but being swamped by the averaging of the official noise metric. By selectively submitting noise data from planes that annoyed them, they were using the app to include their sensation within the regulatory 'reality' of noise that they felt excluded from. In a similar way, the local pressure group focused on the quantity of participants taking part in the noise monitoring campaign, yet largely ignored the decibel data. The monitoring campaign generated significant media publicity and the pressure group emphasised the act of public measurement as a mass protest against airport expansion. What mattered politically was the performative act of measurement and the quantity of participants rather than the epistemic content of the data. Finally, a local council made use of the generated data as the basis of their official response to the government's consultative document on the third runway. They also did not focus on the decibel content of the dataset but highlighted qualitative textual descriptors used by residents and reframed the measurements as official noise complaints. Thus the existence and size of the dataset became evidence for the failure of the current institutional noise metrics to account for the experience of residents. In this way, the app became a prototype for the new kinds of sensing devices that would be needed to better represent the residents' sensation of aircraft noise.

What these enactments of the app had in common was that they did not rely on epistemic chains of reference towards calibrated reference sensors or claims to the authority of science for their legitimacy. By politicising the supposed neutrality of the existing noise metrics and providing an alternative approach, these concern-based enactments managed to bypass reference devices as gatekeepers to environmental decision-making. The local actors validated their ontologies of noise by providing evidence of the strength of their concern via numbers of participants, intensity of complaints and media coverage of the monitoring campaign. The resulting legitimacy of these ontological translations was strong enough for the council to base their official response to the airports commission on the WideNoise app. In this case, the ambiguity of what the 'neo-environmental' device was sensing, offered potential for the local actors to translate the device, the act of measurement and the data into 'matters of concern' (Latour 2004). The case study demonstrates that while 'neo-environmental' sensing can create problems for pollution-affected communities when using an epistemic 'information power' approach, it can also allow the construction of new environmental realities.

Supporting ontological reconfiguration

My gut feeling is that 'neo-environmentalism' is here to stay and will continue to grow across a variety of different domains, as environmental politics becomes more technology and publicity driven. Yet rather than try to oppose this trend to return to naturalistic visions of stable epistemic data, my suggestion is that the trend presents researchers with an opportunity to shift towards a new approach and role. STS has long focused on analysing environmental controversies as epistemic conflicts of expertise and knowledge politics (Wynne 1992; Yearly 2000) and advocated on behalf of communities to articulate their knowledge claims. Yet arguably this approach is less useful in situations where environmental controversies revolve around ontological conflicts. I suggest that, in those cases, researchers should engage with the disruptive potential of 'neo-environmentalism' to redirect it towards multiplying realities as ontological politics (Mol 1999). Because 'neo-environmental' devices don't offer epistemic certainty, the devices invite a critical approach to controversies that politicises the way institutional standards function ontologically to exclude the realities of pollution-affected communities. I see a lot of potential in Marres (2013, 12) suggestion that 'ontology must be experimentalised', and that researchers should work with

> the deliberate investment of non-humans with moral and political capacities. Here objects, and by extension ontologies, have political and moral capacities 'by design'.

This chimes with the way participatory designers use the notion of 'infrastructuring' (Björgvinsson et al. 2012; Dantec 2012) to embed the designer within a controversy and a community to support them over an extended period of time. My suggestion is that like neogeography, 'neo-environmental' sensing could become a movement for doing the environment 'differently', by working with local groups to support them in carrying out ontological translations. In the WideNoise study, the collaboration between the university researchers and the pressure group was critical for staging the sensing device in such a way that the multiple environmental enactments could take place. By focusing on the translation of 'smart' data into matters of concern, academic researchers could shift into a role of supporting communities in constructing new environmental ontologies.

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* * *

Open Data in the Private Interest

Meg Young

Twin goals of the open data movement

Open data embraces a vision of public participation, collaboration, and transparency. At the same time, it is intended to foster efficiency in government via private enterprise competition and innovation. To the extent that these twin goals are expressions of those behind the open data movement, they parallel a tension rooted in the liberal tradition between freedom and property (Coleman 2013); a tension which manifests at the fault lines of the Free vs. Open Source (F/OSS) software development communities.

Whereas Free software licenses collaborative work with no restrictions on distribution, modification, or use, Open Source development products are proprietary. Nathaniel Tkacz traces the roots of the 'open government' movement to an open source rationale, as it is "business-backed" and "compatible with a new form of capitalist accumulation" (Tkacz 2012, 393, 395). While the open data movement is conceptually distinct from its open government and open source kin (Schrock 2016), its conceptual heritage carries the same tension between egalitarian collaboration and private sector innovation. Here, I draw from observations in my fieldwork in Seattle, one of the earliest municipal open data programs in the US, to surface how the private sector has shaped its design and execution.

Open data programs are consistent with longstanding neoliberal goals to make government more efficient by applying market logic to government and embracing disaggregation, in an effort known as New Public Management (Longo 2011; Bates 2012). From the outset, President Barack Obama claimed that open data can foster cross-sector collaboration "with nonprofit organizations, businesses, and individuals in the private sector" (The White House 2009). Seattle's CTO cited two goals for its new open data program, saying, "With new, constrained government budgets, we're able to leverage a large community of people outside government to make government… more accessible to everyone" (Socrata 2010). In both cases, open data initiatives were advanced to cut budgets while fostering private enterprise.

At the same time, open data discourse focuses on public engagement and access. To the extent that the private sector is acknowledged in civic hacking discourse, the emphasis is on local software entrepreneurship (Barns 2016) and local social good outcomes (O'Reilly 2013). The 'civic tech' space frames the users of open data as local civic hackers and social entrepreneurs (Goldsmith and Crawford 2014; Goldstein and Dyson 2013). From the early days of U.S. open data, a non-profit called Code for America worked with volunteers to promote and build usable, intuitive interfaces on public-facing government services, earning comparisons to the Peace Corps (Wadhwa 2011). Seattle's local brigade convenes data enthusiasts to work on projects with a local focus (Young and Yan 2016). In turn, Seattle's municipal government embraced a public engagement strategy, creating a position for a Civic Technology Advocate to encourage local citizen participation. Even as municipal open government data initiatives promulgate a discourse of data in the public interest, the 'public interest' is defined in a way that circumscribes private companies and the monetization of public data. Indeed, a primary goal of Seattle's open data program was to stimulate the local economy in the wake of the global financial crisis (interview, Jan. 23, 2017).

Uses and users of open data

Neither civic hackers nor local entrepreneurs are the primary users of open data—large companies are. Companies like Zillow and Yelp commercialize civic data, which trade literature refers to as "unlocking its value" (Manyika et al. 2013). The data broker industry, including companies such as Acxiom and Experian, are under-represented in open data discourse relative to their outsize use of it (Federal Trade Commission 2014). Recall that Marquet (this issue), describes volunteers who make open and collaborative map data "bewildered" one day to discover Google Maps had been hired by another SNCF subsidiary to do the same work. This moment illuminates vying interests in the production of municipal data, and local civic hackers' surprise to find themselves competing with such behemoths.

To be clear, private interests in open data do not preclude social good outcomes. Many private sector partners perform an important role to make government data more accessible, usable, and valuable to municipal residents. For example, New York City based company SiteCompli tracks local regulations, inspections, and violations, helping developers keep their properties safe and up to date. Other companies use open data to unjust ends, such as

charging for access to otherwise open data, or using open data to compile dossiers on individual residents. The data broker industry generates billions of dollars a year (Federal Trade Commission 2014).

Corporate open data users describe themselves as intermediaries, working on behalf of the public to derive value from otherwise inscrutable raw data assets. In his comments to public sector personnel at a 'customer summit,' one CEO commented, "You need our participation to effectuate the changes you are trying to make" (Renninger 2015; Socrata Customer Summit video 2014). The speaker goes on to provide the following diagram of the 'open data triangle,' in which private facilitators (and Socrata) "tak[e] data [from government] transform it, and provid[e] real value" (Ibid.) Many Seattle employees share this perspective; arguing that sharing data allows municipal governments to "better to focus on our strengths and let Google figure out how to get people around town" (interview, March 10, 2015). Here, I take a closer look at Seattle's open data platform host, Socrata, to surface differences between civic hackers and the private sector as open data users. Socrata is has a private-sector, proprietary software-as-a-service solution for hosting government data. It hosts hundreds of open government data programs, and provides a suite of web tools for user-friendly data analysis. The City of Seattle pays Socrata an annual fee to run its Open Data Platform, data.seattle.gov (known locally as "DSG"), with optional add-ons for data visualization services like the Open Budget application (Levine 2017).

Figure 3 – Socrata Customer Summit 2014 video; Slide from presentation by CEO of SiteCompli, Ross Goldberg

Vendor services adopted for pragmatic reasons have unintended consequences in that they are private sector entities serving a public role. At the time of this writing, there is only one person from Socrata's 200-employees whose job is to answer requests from civic hacker users, even as the company serves more than 100 municipalities. A focus group with local civic hackers describes Socrata as a barrier between Seattle residents and their government:

A market niche has appeared of intermediary companies…These guys are now our front-end, and they merely shifted it to a closed [one], and it being a closed corporate model actually exacerbates [access issues], because then there's little ability to influence the scheduling of those projects or even the technical capability. So, I have a fear that those intermediaries will inadvertently become a larger barrier than dealing with a government agency that I can always hit with a Freedom of Information Act [request]. You know, pound on the desk—I'm a citizen!" (Focus group, Code for Seattle February 12, 2015).

Rather than understanding industry as a facilitator to public uses of open data, this respondent understood it instead to be an additional interloper, if not a barrier.

Civic hackers also feel limited by the suite of tools and functionality on Socrata's platform, and find data quality issues (Young and Yan 2017). In this volume, Hoyng (this issue) anticipates these challenges, saying that:

Although the Open Data discourse hails transparency as a democratic-political value, the protocol is not positioned as a right but rather as a service, meaning it exists at the state's discretion.

Under resource constraints, open data platforms must make choices that have consequences for what their intended uses and users will be. While Socrata has made efforts since 2015 to improve the usability of the DSG platform, it has advanced an initiative in the meantime to open a parallel solution, targeted toward meeting the needs of commercial users.

Private company users of the open data network

This latter platform is called the 'Open Data Network' or ODN. Open Data Network is a strategic partnership between Socrata, Yelp, Zillow, SiteCompli, and other companies to make open government data more amenable to enterprise uses. It does not cost any money to partners or municipal governments for their data to be used in this effort. Since 2015, Open Data Network has morphed into something akin to a public-facing search engine for open data, which will eventually index all open data available across jurisdictions, especially that of Socrata's customer governments. A state employee who leads its open data program sees ODN as a "huge" value add for public agencies, in that it increases the findability (and usage) of their open data (interview February 15, 2017). The long-term vision for the project has evolved from a 'search engine' to an interface akin to WolframAlpha that can answer natural language queries. Most crucially, the partnership generates cleaned and standardized data assets to make them easier for enterprises to use across jurisdictions.

ODN centralizes data for large companies to pull this standardized data from a single source. In making it interoperable across jurisdictions, Socrata situates itself as the obligatory passage point in its partners' enterprise data use (Callon 1984, Söderström et al. 2014). Courmont (this issue) finds that actors that consolidate data foster a new locus of power; "the consolidated data is a boundary object allowing the coordination of various actors through a common representation of the urban space. The consolidation gives the producer new regulation opportunities by gathering these actors around his data" (Courmont this issue). An employee at Socrata explained that such standardization and reach will facilitate ODN partner companies to expand across geographic markets. However, the transformations and cleaning done to the data to prepare it for ODN are not synched back to customers' own platforms, like DSG, the primary means by which Seattle's civic hackers access data.

Through a platform studies lens, Socrata's division of its services into two open data platforms indicates this divergence in the uses and users it serves. Van Dijck (2013) combines political economic and Actor-Network approaches to examine how the design of platforms influences users and content. Adapting van Dijck's approach helps us to view Socrata with a critical eye towards the distinct missions of data.seattle.gov and the Open Data Network. Her work surfaces urgent questions about platforms' ownership, governance, and business models.

Relationships between public agencies and partnerships like ODN have persuasive power. Recall another case study in this issue, the Open Street Maps (OSM) partnership with Transilien, which is described as a “Trojan Horse” - “a nice way to easily open up the doors of municipalities” (Marquet this issue). Similarly, ODN has fostered an initiative to set open standards for local governments. These standards specify the structure, metadata and formats in which housing sector data would be more useful to partners like Zillow (Renninger 2015). Few competitors are participating in this effort; Zillow thus gets an amplified voice in the types of data that cities should be releasing, and the standards that will apply. In the UK, Bates (2012) similarly found that open data was produced at “marginal cost (generally zero)” to provide a marketable asset to private industry. Privately produced standards for open data have rhetorical pull with public agencies, which are purposed to “unlock” local economic value for companies and residents via the release of machine-readable data.

Insofar as the Open Data Network is a nascent municipal open data standards organization, it is advantageous to participating companies. Busch points out how the process of standards-making is also a type of power:

> However much standards appear to be neutral, benign, merely technical, obscure, and removed from daily life, they are, I argue, largely and unrecognized but extremely important and growing source of social, political, and economic relations of power. Indeed, in our modern world, standards are arguably the most important manifestation of power relations… [which are] present only when [they are] performed or enacted (Busch 2011, 28).

Standards indeed increase the usability and interoperability of multiple jurisdictions’ data, but they also shift the labor of making data usable from within Zillow – which previously had to clean or standardize data it takes in – to the workforce within municipal governments. This case provides evidence of “the difficulty for keeping standards for things and those for people apart;” changing standards data publication re-configures personnel, labor, and organizations in turn (Busch 2011, 26).

The power of ODN lies in its ability to set priorities and informally lobby its customers to spend resources on opening data that partners find valuable, such as real estate data, via the domains it chooses to release standards. Municipal data is not frictionless to open (Denis and Goëta 2017); it must be collected in a machine-readable format, assessed for risk to privacy and liability, redacted where needed, curated via metadata and data dictionaries, and sent to Socrata’s intake system (and updated manually or automatically). This labor and time may be directed into any number of open datasets that would be useful for research, social justice, or improving public services. However, ODN could persuade governments to emphasize commercializable datasets for release at the expense of others. As governments move forward with open data programs, a greater appreciation of the distinct public and private interests in open data will help to make more purposeful decisions about which datasets to open, and to what end. Given the labor, resources, and time that governments dedicate toward preparing datasets for publication (Denis and Goëta 2017; Courmont this issue), these resources should be expended with a clear idea of the intended outcomes in mind.

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Geoffrey C. Bowker, Stefan Timmermans, Adele E. Clarke and Ellen Balka (eds.)
Boundary Obects and Beyond. Working with Leigh Star, Cambridge, MA, MIT Press, 2016, pp. 560

Alessandro Narduzzo *Free University of Bozen-Bolzano*

This book is the result of a conference that fellows, students and co-authors dedicated to the beloved scholar, Leigh Star, to celebrate her inspirational work. The book's editors avoided the favourable tone that is typical – and to some extent, involuntary – in such works, by putting together a balanced selection of essays *by* Star and *on* Star, which flows seamlessly and ultimately provides a rich and precise portrait of the scholar. The book ultimately covers not only her intellectual contributions to scientific knowledge, but also her mindful self-reflection on the role of researchers in society as part of an epistemological discourse. Altogether, the book provides a thick web of reflections displaying the potential of Star's intellectual contribution and suggesting possible directions in which to extend her work.

In fact, one major trait that characterises Star's legacy relates to her influential contributions across a wide spectrum of scientific domains. This is exemplified by her most cited publication, where Star and James R.

Griesemer introduced the concept of "boundary object" (addressed in Ch. 7). It is worth to get back to Star and Griesemer's definition. For them, a "boundary object" is an object that is "both plastic enough to adapt to local needs and constraints of the several parties employing [it], yet robust enough to maintain a common identity across sites". Therefore, a "boundary object" is "weakly structured in common use, and become strongly structured in individual-site use" (pp. 176-177). Because of these features a "boundary object" can have a different meaning in different social worlds, but its structure is common enough to make it recognisable, so that it can work as a means of translation.

It is worth noting that citations of Star and Griesemer's article appear in publications across more than 90 research areas. The top three areas in terms of the number of citations, based on the Web of Science classification, are Business Economics, Computer Science, History and Philosophy of Science; Sociology comes in at the sixth place. Such an influential presence across various distinct fields not only qualifies the relevance of Star's scientific contribution, but also suggests that her theorisation is a boundary object in itself, being plastic enough to be adopted as a tool for research investigations by various scientific communities, while preserving its own identity.

Dick Boland (Ch. 10) effectively explains why and how the concept of boundary objects was so influential in management and organisation studies. The concept demarcates concrete and situated things that actors with heterogeneous knowledge can use and refer to, while cooperating and working together, without setting or agreeing on the nature of the objects, actions or goals to be achieved. Further, this concept brings in a perspective that is entirely different from what was previous offered by semiotics, where symbols may be ascribed different meanings by different people but the spectrum of those meanings is constrained within a space of mutual understanding (i.e., individual expectations on everyone's meanings).

In a similar vein, Griesemer (Ch. 8) reflects on the ideas discussed by Star and himself at the time they were elaborating on the concept of boundary objects, from the perspective of Science and Technology Studies (STS). They wanted to develop a "heuristic methodological category to think with as much as an ontological category of object to think about" (p. 207). Thus, the concept of boundary objects has both epistemological and ontological consequences. In the former case, it provides STS with a methodological tool that increases standardisation across studies and, therefore, scientific rigor. As for the latter, the concept embodies the complexity of relationships among agents at multiple levels (e.g. meanings, action, goals) of interaction.

As anticipated, the concept of boundary objects became extremely popular in various fields, causing its core meaning to be undermined. Star (2010), in turn, was compelled to explain and elaborate on what a boundary object is not. On the one hand, she expanded the concept by clarifying that boundary objects are not restricted to the four types mentioned in her 1989 work, namely, repositories, ideal types, coincident boundaries and standardised forms. On the other, she called for a deeper analysis of boundary objects to incorporate their organisational structure, as well as their intrinsic processual dimension, as connectors of cooperative work. The emphasis on the organisational structure of boundary objects led Star to reflect on systems constituting boundary objects that she identifies as infrastructures, a conceptualisation that also occupies a special place in Star's theorisations as well as in her epistemology. The centrality of this concept and its ramifications can also be observed in the writings selected for this book as the idea of infrastructure is relevant in a number of essays (i.e. Chs. 2, 7, 20, 21, 23, 24); this includes the seminal paper written with Karen Ruhleder (Ch. 20) on the design, development and use of WCS – the Worm Community System – which is a data repository as well as a platform to support the formal and informal communication of a distributed community of biologists, who are active in more than 100 different laboratories around the world. Through this study, Star and Ruhleder outlined their theory of infrastructure. Infrastructures are scaled-up systems of boundary objects, inheriting from the latter their relational and ecological nature: they "mean different things to different people" and are "part of the balance of action, tools and the built environment, inseparable from them" (p. 473). Infrastructures both anchor and are anchored to organised, context-dependent practices. Star characterises infrastructures in detail as embedded and transparent, but visible upon breakdown (i.e. infrastructural inversion); as able to support tasks and practices; as able to afford membership in a community of practice, which evolves in a mutual adjustment with infrastructures.

Star leverages the concept of infrastructure to develop some critical insights on the realm of the philosophy of science. In her view, science is conceived as a socially constructed ecology of knowledge (Ch. 1). Consistent with the STS approach, Star's analyses of science and technology includes the process – and not only the product – of the production of scientific knowledge to unveil what is otherwise taken for granted as scientific infrastructure.

"As chains of causation are simplified and purified, the standard indicators they are built on become substitute theories. We forfeit the infrastructural conditions that afford us the possibility of formulating alternative explanations" (p. 432). When the understanding of a phenomenon essentially relies on dominant chains of causal relationships, supported by infrastructures such as standard indicators and tools, this understanding expunges, as residual evidence, anomalies that would provide the grounds for richer insights into that phenomenon.

Furthermore, Star enhances her reasoning on infrastructures by offering thorough reflections on the methodological challenges posed by this concept (Ch. 24). The study on WCS is the result of fieldwork spanning three years; despite a strict adherence to the principles of participatory design, the new system was disregarded by most biologists. This disappointing result led the research team to deepen their analysis of the situation and, ultimately, to better understand how critical and intensive the relational nature of infrastructure was.

This book can claim many merits. The selection of essays offers an excellent resource for scholars interested in understanding and tracing the origins of very influential concepts (i.e. boundary objects and infrastructures), the research questions that sparked them and how particular empirical settings influenced their formulation. This book will also be useful for researchers, such as PhD students, who are deliberating on the methodological aspects of their work. In fact, although the book is certainly not meant to be a handbook on methodology, it offers rich and rigorous reflections on fundamental methodological themes from the first-person perspective and deeply reflects the common emotional and cognitive identity of researchers.

On this point, a representative example is offered by the notion of "triangulation from the margins", as described by John King (Ch. 17). Triangulation is certainly a widespread practice in the social sciences to improve the understanding of complex phenomena. Star questioned the idea that this understanding could be achieved by primarily triangulating the narrative of those who have the most to gain or lose. In contrast, Star theorised the importance of triangulating using the narratives of those who exist in the margins: these individuals can observe elements, which are totally neglected by the dominant views, and therefore, they contribute to the enrichment of the triangulation through insights that would otherwise be lost.

As Leigh Star writes, "as a graduate student, I searched for years for teachers who would not try to divorce me from my life experience, feelings, and feminist commitments. At the same time, I didn't want just a 'touchy-feelings' sort of graduate education. […] I was looking for a way simultaneously to incorporate formal and informal understanding" (p. 122). For those who recognise themselves in such yearning, this book will certainly offer an opportunity to reflect on their own path.

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James Evans, Andrew Karvonen and Rob Raven (eds.)
The Experimental City, London, Routledge, 2016, pp. 280

Claudia Mendes and Pim Peters *Technical University of Munich*

Evans, Karvonen and Raven's *The Experimental City* is a timely contribution to a growing body of literature on urban experiments – for other recent literature see (Castán Broto and Bulkeley 2013; Karvonen and van Heur 2014; Laurent and Tironi 2015). Yet, the current edited volume is distinctive in that it brings together contributions from a variety of disciplines such as transition studies, urban studies and STS. This combination is not always easy or without frictions, but provides the reader with a rich variety of conceptual sensibilities and insights. Urban experimentation on the one hand appears as holding a promise for realizing a more sustainable organization of urban life and overcoming resistance to change, on the other hand, it is also presented as ambivalent and highly political activity requiring careful examination and continuous critical engagement.

With a strong empirical focus, the volume takes the reader on a journey through case studies from regions as diverse as Ghana, Chile, Abu Dhabi, Korea and the UK, to name just a few, thereby showing the prevalence of urban experiments but also the diversity of phenomena taken into account. Some of the volumes stand out chapters for an STS audience include a critical analysis of "cabin ecologies" developed to protect humans in hostile environments (such as space) and a their links to currently emerging "integrated urban infrastructures" such as the Apple campus in Cupertino (Marvin and Hodson), an interrogation of the limits to experimentation when it becomes incorporated as marketable differentiator by the property development industry (Rapoport), a critical analysis of the planning, assembling and inhabitation of experiments in "green living" in Santiago de Chile (Sanzana Calvet and Castán Broto), an ethnographic account tracing the modernist vision of a resettlement experiment and its afterlife in local discourse and imaginaries in rural Ghana (Yarrow) and the speculative but thought-provoking sketch of a potential post-carbon city (Pincetl).

The presented case studies range from bottom-up to top-down initiatives, highly controlled environments to *in vivo* settings, projects branded as experimental and practices spontaneously emerging as such, thereby showcasing different conceptual and empirical enactments of the main issue at stake: the experiment and its relationship to the city. A recurring feature throughout the volume however, is an understanding of the experiment as an arrangement for exploring working relations in order to "prompt genuine change" (p. 1) – to put it in the words of the volume editors – towards more sustainable ways of organizing collective urban life. This is a clear departure from the "classical" understanding of the

Chicago School, which, as argued by Gieryn (2006) understood the urban laboratory as a “restricting and controlling environment, whose placelessness enables generalizations to ‘anywhere’” (Gieryn 2006, p. 7). By contrast, most contributors to the current volume do not seek to construct such “placeless places”. Experimentation here appears as a broad range of different activities that share the capacity to engender reimaginiation, redescription and rematerialization of existing urban realities with regard to sustainable development. Throughout the chapters one may however identify different conceptual and empirical takes on this.

One distinct understanding of this city/experiment relationship is exemplified by Ch. 5. Here, cities appear conceptually as “complex adaptive systems with significant embedded dependencies built-in over the years of their construction” (p. 62). This approach, influenced by transition studies, foregrounds how the functioning, or failure of integrated infrastructures crucially shapes the functioning of human and nonhuman urban life and implies a notion of the experiment as virtual but indispensable prerequisite for successful change. Seeing the city as a set of layered and interconnected socio-technical systems leads Ryan et al. to conclude that “trying to re-engineer the city one sub-system at a time is bound to fail because new, often unpredicted, problems are likely to arise in another sub-system” (pp. 63-64). Therefore, they argue, a transition to a “resilient non-carbonaceous city” can only be realized through “a (rapid) transition from one set of socio-cultural technological-physical systems to another set” (p. 64). Experimentation in their view then, is a virtual exercise meant to test and build up these alternative subsystems and to prepare the grounds for the proposed rapid transition.

A second type of urban experimentation is explored in Chs. 14 and 16. Both analyse the case of Masdar, a so called “eco-city” planned from scratch and currently under construction in the United Arabic Emirates. Despite different foci, the authors share the observation that Masdar City is rather a fragmented clean-tech testing site, where too many actors – often profit-driven – through too many experiments – mostly product innovation – fail to assemble the promised eco-city. By the actors involved in Masdar’s development the city is thus not so much perceived as a complex socio-technical system or itself the object and target of experimentation, but rather as a tabula rasa, where technological experiments can be staged and commercial solutions to sustainability issues demonstrated. However, as such, so the authors argue, this disconnected type of experimental platforms fails to induce sustainable urban development and to generate knowledge on the deployment of clean technologies in more complex and liveable urban contexts, that could lead to wider social transformations.

A third way of relating experimentation to the city is suggested in Ch. 11. Jana Wendler presents an ethnography of a community garden in Berlin as an alternative, emergent and bottom-up space for experimentation with social organisation. In her account, experimentation is not at the outset of a policy or company driven project, nor is it explicitly designed as such. Instead, the grassroots community garden project develops over time – or organically, as the author puts it – into an alternative urban space, where different and unforeseen experiments can happen and individual as well as community learning can occur. The complex spatial and social entanglement of the community garden with the wider urban context allows, according to Wendler, "to take up a distinct and valuable role in processes of urban change" (p. 161) which is more open to diverse and sometimes marginal actors. In this conception of "open, extended real-world experiments" (p. 159), instead of virtually testing alternative futures or staging technological innovation on a tabula-rasa, experimentation is a highly situated and embodied activity, that "allows big issues to become knowable in everyday mundane, small-scale practices through the affective relations between body and material", but does not serve as a "replicable blueprint" (p. 160) for other cities.

What these spot lights demonstrate is certainly the sheer diversity of practices and projects that are being theorized as experimental cities or urban laboratories. But they also show what Evans et al. point out in their introduction; namely that "Experiments, understandings of experiments, and the attendant future visions they entail, are not inherently positive but carry politics just like any other development strategy" (p. 3). While STS readers may find that not all approaches chosen in the book are being equally attentive to these politics of experimentation, the rather broad and open minded approach to urban experiments adopted in *The Experimental City* certainly succeeds in mapping out a huge field for future research and conceptualisation, where a stronger involvement of STS scholars can be of benefit.

The relevance of STS engagement becomes especially clear in light of the books wider context. As Maarten Hajer points out in the foreword we are currently witnessing a "turn to experimental governance" (p. xviii), not just among scholars but also in practice. However, and this should be no surprise to an STS audience, scholarly publications like *The Experimental City* do not merely describe this experimental turn but actively contribute to it. Recent work of Hannah Knox provides a telling example of such performative effects of social theory: Knox describes her ethnographic encounter with Zeb, a British IT entrepreneur working on how "digital technologies might provide solutions for climate change" (Knox 2017, 356). As Knox explains, Zeb's own work is inspired by that of Frank Geels (2002) and other transition scholars, some of which contributed to the current edited volume. Based on this encounter Knox argues, that "new techniques of governance – the experiment, the unaccounted for action, the re-description and re-imagination of already existing practices as the basis for future action are crucial for understanding how contemporary governmental actors are imagining and formulating infrastructures of the future" (Knox 2017, 363). Such observations of performativity do not only affirm the relevance and timeliness of *The Experimental City*, but also the importance of substantial STS engagement with the issues it puts forward and the types of cities it enacts.

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Jennifer Gabrys

Program Earth. Environmental Sensing Technology and the Making of a Computational Planet, Minneapolis, University of Minnesota Press, 2016, pp. 368

Caspar Menkman *Maynooth University*

Program Earth is about the becoming environmental of computation. In this book Jennifer Gabrys attends to the (per)formative role that calculative and sensing technologies play as part of everyday and extraordinary environments. These spatializing properties have previously been remarked on in other academic disciplines. For instance authors in computer science (Weiser 1993), social science (Kitchin and Dodge 2011), and media studies (Hayles 2009) have emphasised the complexities that arise as coded technologies and spatial operations become mutually dependent.

What makes Gabrys' contribution to this discourse distinctive is her propositional approach. She presents the reader with an engaged narrative on the role of sensors, computation, and associated technologies as part of everyday environments. Throughout the book she introduces encounters that range across different environments and involve different actors with wholly different intentions. In some of these, technologies are made explicitly visible, while others show them as part of the background, quietly going about their work. However, what all they have in common is the formative role of sensor technologies. In *Program Earth* Gabrys asks the reader to reflect on what this means. And, to accomplish this effectively, she develops a set of theoretical and philosophical assertions that carefully position the public alongside environments and technologies. Such an appreciation, she argues, can change how we are part of environments, how environments function, and how otherwise distinctive spaces are able to relate to each other.

The book could possibly have been called "Programmable Earth". Whereas a program refers to a structure that is followed, Gabrys intends to describe something else. She sets up computation, code, and data as part of encounters between environments, devices, and other entities to show how they become together. This approach is distinct from utilitarian narratives that promise technology's immediacy, neutrality, or efficiency; and equally from those critiques that point towards programmatic or disciplinary capacities. For Gabrys, sensors enable an "expanded engagement with programmability" that helps to consider "how code is not a discursive structure or rule that acts on things, but rather is an embodied and embedded set of operations that are articulated across devices, environments, practices, and imaginations" (p. 41). This distributed approach to action and encoding, links her work to theorists of more-than-human relations (Haraway 2016), co-production of politics and space (Jasanoff 2004), or other literatures that are hesitant to accept *ex ante* normative categories or deterministic relations. That is not to say that power and the potentials associated with technology are forgotten. A recurring theme is the distributed spatial effects including the issues that arise with access, constraints in use, and skills. However, her focus remains with interdependencies and the productive qualities that emerge from these operations.

Program Earth consists of three sections: "Wild Sensing", "Pollution Sensing", and "Urban Sensing" and each is made up of three chapters. The sections represent distinctive epistemic projects wherein sensors together with humans and non-humans constitute directed techno-geographic milieus. In the individual chapters Gabrys settles on a handful of empirical examples that follow comparable logics to illustrate a particular, often theoretical, contribution. While the chapters can be read individually, as they are relatively self-contained, all of them rely heavily on the introductory chapter. Throughout these first thirty pages the reader is familiarized with the author's spatial thinking that comes from constructivist roots, with Whitehead, Simondon, and Stengers being the primary interlocutors. Here she also introduces her key spatial metaphors: environment, milieu, and ecology.

The section on "Wild Sensing" describes remotely monitored environments that primarily serve human learning and understanding. This topic is explored to illustrate how sensors act on existent environmental relations. While the adjective "wild" in the section's title suggests these spaces are typically not considered subject to human intervention, the assumed distance between observed environment, the technologies that monitor, and other entities enrolled in the process of observation is questioned. Gabrys does this by stating that within these environments sensors operate "not as instruments sensing something 'out there' but rather as devices for making present and interpretable distinct types of ecological processes" (p. 29). Sensors and networks do not just extend the reach of people, but equally make environments show up as active. This fits with recent work in STS that turns to ontology (e.g., Law and Lien 2013) to focus on the contingency of events, objects, and entities. In doing so, Gabrys shows the generative potential of sensors to produce and couple previous unconnected environments with contextual knock-on effects.

A demonstrative example is Spillcam, a stationary webcam installed to livestream the 2010 BP Deepwater Horizon oil-spill. Gabrys shows how a single camera allowed for the distribution of interest to this environmental disaster by enabling the formation of new spaces, practices, and identities in response to it. It visualised the ongoing crisis, the scale of which would otherwise remained largely inapproachable and hidden to the general public. While turning to such a vision of an event evidently also leaves things out, the overarching thesis of the chapter is that sensor-based monitoring can draw those not immediately present into a relation to particular events.

In the chapters themed "Pollution Sensing" Gabrys explores the status and potential uses of sensors as having an impact on the coding of environments. By doing this, she strikes a more political tone as strategic and speculative applications of data to environments are considered. These, she argues, can contest otherwise taken for granted environmental relations. So where the first section explored how environmental relations work, here she qualifies what uses they afford to those affected by them. This involves the tapping into alternative repertoires of knowledge and possibly the remaking of environmental relations.

For example environmental citizenship is introduced as a category that runs counter to modern state-bound definitions of belonging. As the becoming part of a milieu, it proposes more open-ended ideas around who or what should have a stake in the politics of environments. Gabrys inverts the "politics of environment" to "environmental politics" and extends membership to all entities with a stake in it. An environment's politics, she speculates, can be produced from within instead of being imposed from without. This is illustrated through sensor technologies that can act as speculative tools enabling positive engagements with complex issues like climate change, that for once do not have to pass through the state. Moreover, the assertion that sensors and the data they generate are relevant to how environments are performed comes with the consideration that this requires new forms of sensor-based participation. This revelation results into questions like: "What experimental forms of politics and environmental practices might we develop that are able to attend to these indeterminate and emergent matters of concern?" (p. 155).

Finally, in "Urban Sensing", Gabrys explores the potential of sensors and their networks to curate and control environments. She introduces environmentality as an inherently spatial form of governmentality, to show how sensors can pose a variety of challenges to environments and their constituencies. The smart city is the paradigmatic example of an environment where sensors are part of "universal visions" of lived environments that are "always the same in their striving for optimization" (p. 261). However, as a common thread the author argues for contingency and difference. Writing that there exist important frictions between regimes that privilege processual expediency on one hand and those that value privacy and comfort on the other. Not breaking character, Gabrys develops a set of strategies and tactics to deal with this as "to be simply in opposition is to be already defeated" (p. 291).

One tactic for critical reflection is through the conceptual persona of the idiot. This ideal person does not follow conventions, but instead questions constitutive characteristics that would otherwise be commonsensical. This inquisitive approach to sensor technologies allows a framing that is part of larger infrastructural narratives, where people can move beyond "simple choices" of subjectification between buy-in or opt-out, to more open conversations about alternative modes of engagement that make possible substantive participation in issues involving sensors.

To conclude, Jennifer Gabrys' book is a timely publication that combines empirical insights with a necessary speculative attitude in an emerging field. It complements earlier publications that critique or applaud the utility of sensors by embodying the "could be different" attitude so at home in STS. It works well as a companion with the work from Gabrys' own *Citizen Sense* project as it shows why these trajectories around emancipation, education, and action based narratives are important. Other productive directions are discussions on the democratic potentials of technologies such as those stemming from STS sub-disciplines like the public understanding of science and technology (Irwin and Wynne 2003). The abundance of possible connections the work make attest to its fit as part of the current discourse on science and technology. Whereas by itself it offers a provocative and engaging read. To me its the propositional approach Gabrys follows, in combination with the rich empirical accounts on societally pressing issues, that makes it helpful in challenging the otherwise settled rules and roles of science and technology.

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Markus Krajewski, Jasmin Meerhoff and Stephan Trüby (eds.)
Dienstbarkeitsarchitekturen. Zwischen Service-Korridor und Ambient Intelligence [Architectures of Subservience. Between Back-Corridors and Ambient Intelligence], Tübingen-Berlin, Wasmuth, 2017, pp. 462

Andreas Meier and Edy Portmann (eds.)
Smart City. Strategie, Governance und Projekte [Smart City. Strategy, Governance and Projects], Wiesbaden, Springer Vieweg, 2016, pp. 346

Susann Wagenknecht *Siegen University*

Smart cities, talk of the town. But are we about to construct a new urban architecture indeed – an architecture that will *serve* the needs of our cities better, in more efficient, more sustainable and more participatory ways? These new architectures are hard to see; they are difficult to examine in detail, with nuance and without being blinded by a firework of promises. This is not because there are few "real" smart cities but because they are elusive, half vision and half practice, both municipal politics and global business, sometimes promotional façade, sometimes bland bureaucratic initiative, lauded as transparent while criticized as black box.

A special trick, hence, is needed to get a better picture. This trick, I propose, consists in reviewing two recent, rather distinct book in German language at the same time, reading them against one another. *Smart City,* edited by Andreas Meier and Edy Portmann, is, according to its back cover, a book for city planners, politicians, citizens and researchers in information systems. *Smart City* is full of advice, some of it premonitory, on how to put digital media to use on an urban scale and for urban concerns. The book proposes concepts, models and evaluation strategies in seven chapters: Smart Governance, Smart Participation, Smart Living, Smart Education, Smart Mobility, Smart Energy and Smart Economy – 16 contributions in total.

The second book, *Dienstbarkeitsarchitekturen*, edited by Markus Krajewski, Jasmin Meerhoff and Stephan Trüby, does not counsel but hijack its readers, taking them on a tour through the staff entrance, along the service hallway, beyond hidden doors and to the kitchen wing. With 13 contributions ranging from art history and cultural studies to sociology and media studies, the book explores architectures of subservience (German: *Dienstbarkeit*) – i.e., the carefully installed mechanisms, sophisticated yet unobtrusive, through which service has been achieved in the past and is achieved today. Anna Mader-Kratky (pp. 88-117), for instance, carefully examines the intricate architectural design and the practices of spatial coordination that ensured imperial service at the Hofburg, the Austrian Emperor's palace in the centre of Vienna. These practices increasingly (and in increasingly elaborate ways) isolated lifeworlds at court. Today, however, not emperors but customers rule. Marcus Termeer, in another chapter of *Dienstbarkeitsarchitekturen*, shows how "concierge living" and a renaissance of exclusive, door-manned housing complexes accommodate contemporary notions of service with the help of sensor and surveillance technologies.

The two books complement one another in standpoint and expertise. *Smart City* offers an abundance of technological expertise; it is pragmatic and affirmative, seeking to put emancipatory visions of smart city into practice. *Smart City* is best read as a compendium of infrastructural experiments in urban governance. Its chapter on Smart Participation, for example, contains three articles each of which approaches the challenges of civic participation in municipal management from a different angle. Martina Löw and Lea Rothmann (pp. 73-101) show how smart city initiatives such as electric car sharing are blurring conventional boundaries between private and public space, boundaries constitutive for Western notions of 'good' society. Since public/private spatial relations in smart cities are likely to change, Löw and Rothmann call for more civic education and participation, buttressed by legal regulation. Jan Fivaz and Daniel Schwarz (pp. 103-129) respond to calls for more civic participation by outlining how smart cities, understood as techno-political laboratories, can use data to strengthen municipal democracy. Finally, Susanne Robra-Bissantz and colleagues (pp. 131-150) report from their experiences with an interactive platform for urban development that uses mapping and virtual reality technologies for "hands-on" participation.

Issues of civic participation get particularly salient once smart cities are managed in public private partnership (PPP). As Evgeny Morozov (2017) predicts, companies such as Alphabet are soon taking over vital urban services, a phenomenon he calls "Google Urbanism." Through PPP, smart cities will be equipped with an elaborate integration of sensors, data, Civic needs and services – "smart services" such as personalized public transport or discreet, affordable 24/7 assistance for the elderly. It comes in handy, thus, that *Smart Cities* outlines a way to account for the role of PPPs in models of smart city governance (Walser and Haller, pp. 19-46) while keeping smart cities "open" in terms of data access and participation (Habenstein et al., 47-71). However, browsing through the book's screen shots, diagrams, tables and flow charts raises the suspicion that the social, political and cultural implications of these smart urban service architectures are not yet understood. *Dienstbarkeitsarchitekturen* inspires to explore and frame such suspicions in terms of Kafka's imagery (Balke, 198-226), the imagery of architecture that is supposed to serve (the citizen, the king) but is gradually, and painfully, revealed to be a trap beyond anyone's control.

Dienstbarkeitsarchitekturen conveys a historical perspective, including a chapter about the ubiquitous domestic presence of slavery in the Roman Empire (Eigler and Lämmle, 50-85). The contributions in the book take a distanced stance, highlighting the ambivalent and intricate relations between master and servant, between power and its premises. Stateroom and kitchen wing may be worlds apart, and yet they form part of the same regime of power. Many of the contributions in the book, then, search for the viewpoint from which the fragility—the powerlessness—of power becomes visible. In their analysis of ancient architecture and the domestic life of Roman masters and their slaves, Eigler and Lämmle (71) resort to Hotel California, the 1977 Eagles rock song: "Mirrors on the ceiling, the pink champagne on ice / And she said, 'We are all just prisoners here of our own device'."

Dienstbarkeitsarchitekturen stubbornly returns to these oscillations between technology-mediated service and automated domination (also in Schürer, 288-329). Unflinchingly, *Dienstbarkeitsarchitekturen* focuses upon the power of infrastructures and infrastructures of power, unearthing their – sometimes conflicting (Potthast, 230-266) – regimes of control, visibility and worship. *Smart City*, in contrast, is so attuned to questioned of municipal governance that it largely leaves aside broader issues of governmentality and power. The book has not yet found a vocabulary rich enough to put ambivalence and critique into practice. In *Smart City*, concern is most clearly voiced on the first page of its preface, written by Andreas Flückinger, chief of staff of technology of the city of St. Gallen: "The city of the future must not become the playground of IT-loving urban hipsters, neither a fully-surveilled paradise of leisure and consumption. The city must remain living space for everyone… The city is a community, not a consumer good" (Flückinger, ix). Flückinger seems to sense that well-meaning visions and neatly designed systems, in all their elegance and technical refinement, can go awry. *Dienstbarkeitsarchitekturen*, in turn, illustrates how technological visions and systems have taken effect in past and present, offering ample illustration of both the comfort and the constraint, the warmth as well as the cold discipline that 'subservient' technologies add to our lives—particularly well demonstrated in a chapter on Allan Wexler, an artist whose installations question the functionalism of modern architecture (Ruhl, 369-420).

No book shop, no library will stack these two books next to one another. No algorithm will recommend the one when you are about to purchase the other. But while both books are a good read for their intended audiences, taken together they offer a truly fascinating glimpse of what future research into digitalized urbanity and its infrastructures may look like. Future research will have to navigate the "gap between affirmative and activist" perspectives upon smart cities (Brauriedl and Strüver 2017), a task that requires it all: enthusiasm for heterogeneous cooperation, the willingness to embrace technological futures *and* the capacity to recognize its shifting, oscillating ambivalences.

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Giovan Francesco Lanzara
Shifting Practices. Reflections on Technology, Practice, and Innovation.
Cambridge, MA, MIT Press, 2016, pp. 304

Attila Bruni *University of Trento*

One of my favourite album of past months is *Rock'n'roll Consciousness* by Thurstone Moore. Singer, guitarist and architect of one of the most important bands on the contemporary alternative musical scene (Sonic Youth), thirty years since the beginning of his career, Moore has made a record that in my opinion strikes a perfect balance between 'old' and 'new', tradition and innovation, past and current. It is an album that ranges among different music genres (from rock, through punk, noise and dark, to free jazz and drone-metal) but which creates an amalgam of sounds that make the final result entirely 'natural'. It is a record whose tracks never last for less than six minutes (and in fact, in a couple of cases, exceed ten minutes), but they do not sound 'long', 'boring' or 'repetitive'. Dissonances and harmonies, suspended moments and sonic irruptions, rhythms that slow down and accelerate, are all played with such mastery that the novice and/or distracted listener may even not realize how much expertise lies beneath them.

But these trajectories, where careful composition and free jamming merge together, never lapse into a self-indulgent display of virtuosity or nonchalance because there is always a dynamism and impetus that do not leave time to get bored. In a sense, it is an album that not only expresses the author's approach and musical aesthetic but also asks the listener to position him/herself. The circularity of the melodies, in fact, transports the listener into the piece, and then asks him/her: do you like this music? Too predictable? Too experimental? Compared to what? What music do you usually listen to? What do you like about it?

But above all, what does this have to do with the book subject to this review?

Perhaps nothing. But because of my passion for music, whenever I have to review a book, I ask myself: and if it was an album? What album would it be? In most cases, I cannot find a sufficiently intuitive match to decide to use it as an outline for the review. But this time the match seems wholly befitting.

Firstly, like Moore's record, Giovan Francesco Lanzara's text 'sounds good' in the sense that the writing is enjoyable, rhythmic, rich with analytical concepts and reflections, as well as metaphors and references to art and literature.

Secondly, it is a book written by someone who, following a multi-year research career, expresses his own ideas without citing those of others. Lanzara, who has always carried out his research at the intersection among organization studies, information systems and innovation studies, uses his research findings to reflect both on innovation as a bricolage and practice-based phenomenon, and on the methodological and epistemological principles useful for reading innovation in processual terms. In particular, Lanzara revisits two of his research studies: the first (conducted between 1986 and 1989) concerning the introduction of software for the teaching of music in a music school; the second (conducted between 1990 and 1993) concerning the introduction of video recorders in Italian courtrooms. Rather like some of the sounds in Moore's album, despite the amount of time that has elapsed, both cases 'sound' extremely current and exemplify the different phases, ambiguities, decision-making, imperfections, contrasting interpretations, "translations" (to use the ANT term) that characterize any process and innovation design at organizational level. Moreover, both are narrated with an attention to detail that engages the reader in a sort of "participatory analysis" of what is being recounted. The reader is provided with the tools and materials to follow the author in his narrative. At the same time, in this way, the reader has the opportunity to construct his/her personal interpretation of the events narrated, without this necessarily coinciding with the author's point of view. The search for "interpretative reciprocity" is, moreover, an essential move for the purpose of studying (and understanding) innovation as a processual phenomenon. The author focuses in this regard on the centrality of "backtalk", not so much in the Goffmanian sense as in that defined by Donald Schön (1983), as "reflective conversation with the materials of the situation". But unlike Schön (to whose memory the text is dedicated), for Lanzara "the materials of the situation" comprise not only the interaction among the designer/researcher, his or her partners, and the materials, but also "the researcher's conversations with his own research materials; the researcher's conversations with himself and his own theories; the second-order conversations between the researcher's and practitioners' stories and between their current and previous stories" (p. 42). The study of innovation phenomena therefore necessarily requires an approach which if not longitudinal nevertheless extends over time. Reading innovation in processual terms means giving innovation time to unfold in relation to the different "situations of practice" (p. 21) and to the various actors with whom it will come into contact. During this time, the meaning of innovation can change, and so too can the identities and interests of the actors involved. The flow of this time is characterized by the alternation of "transient" knowledge (and constructs): that is, "knowledge that is created in a process of design and innovation: a kind of transformative activity is carried out, and the knowledge is subsequently obliterated, transformed or transcended by the same activity as the process unfolds" (p. 217). Typically, this knowledge is "embodied in (...) artifacts, minimal structures, recombinant routines, ephemeral practices, incomplete representations and shifting stories (...)" (p. 217). These are "transient constructs" or "embodied hypothesis", that is: "hypothetical statement about how an object or tool could look, how it could or should be used, how the situation could be understood, and how the world could be organized" (p. 222).

Transient knowledge and constructs are ephemeral. Consequently, people often lose track and memory of them. But for Lanzara they are the moments on which it is most interesting to dwell in order to understand the trajectory of an innovation. While knowledge and constructs are ephemeral, they are also transient in the sense of "transitional", thus providing a "provisional 'anchoring' to some features of the situation that can be handled" (p. 224). It is therefore in these partial articulations and definitions that innovation takes shape, embodying materials, objects, ideas and interpretations that are sometimes lost, while others persist over time, but which in any case act as "temporary scaffolds for building new forms of knowledge and agency" (p. 246).

More than asserting a series of statements, therefore, Lanzara's text asks a series of questions: "What happens in an established practice or work setting when a novel artifact or tool for doing work changes the familiar work routines?" (p. 5); "What is revealed of a practice in the switch to a different medium? How are objects, activities, representations, and skills affected by the nature of the medium? How are our perceptions and idea of materiality and reality mediated by the medium? How is knowledge itself medium-dependent? And (…) in what sense is a practice a mediated world?" (p. 203). Moreover, "To what extent can an observer legitimately penetrate into the representations of the actors observed? What kinds of access are technically rigorous, socially feasible, and morally acceptable? To what extent is digging deeply into the actors' representations also a form of intervention, or perhaps intrusion, into them?" (p. 253); "How can an experiment be designed that would enable both the researcher and the practitioners involved in the project to develop relevant knowledge about the innovation process and reflect on their own theories, strategies and experiences while they are actually engaged in action?" (p. 37); "How does the subtle line between what is remarked and questioned and what instead goes unremarked and unquestioned affect the researcher's reconstruction of reality?" (p. 46); "When does the researcher notice the tools being worked with and the equipment on which she or he relies for carrying out ordinary research work? When are the things that surround her or him and support routine operations seen?" (p. 47).

As in the case of some of the sounds in Moore's record, there will certainly be those who say that they have already heard these questions (and, perhaps, have already found the answers). However, for Lanzara questions serve to problematize reality, and if they are well formulated, they lead to further questions, more than to definitive answers. From this point of view, it can indeed be argued (as Lanzara does) that: "what is fixed as the reality – the accepted facts, the known events, the shared truths – also constitutes the experiential and cognitive limit of the inquirer, marks the boundaries of the hitherto known world, and the nature and quality of social interaction. And what is called reality coincides with the place and time in which the practice of reflexivity gets suspended" (p. 265).

Just as the keyword of Thurston Moore's album is not so much "Rock'n'roll" as "consciousness", so the keyword of Giovan Francesco Lanzara's text is not "practice", "technology" or "innovation" but rather "reflection". And reflection (like music) is never-ending.

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Bruno Latour
Piccola filosofia dell'enunciazione (con una nota di Jacques Fontanille)
[*Tiny Philosophy of Enunciation (with a note by Jacques Fontanille)*], Roma, Aracne, 2017, pp. 68

Alvise Mattozzi *Free University of Bozen-Bolzano*

Providing an autonomous format to Bruno Latour's 1999 article "Piccola filosofia dell'enunciazione" [Tiny Philosophy of Enunciation] with both the original French version and the already published one in Italian, was the right move. Now that some years have passed since the publication of *An Inquiry into Modes of Existence (AIME)* (Latour 2013), it can result extremely useful to have at hand one of the sources, and one of the steps towards, *AIME*, in order to better understand and appreciate Latour's trajectory in its entirety.

This new version of Latour's article is accompanied by a useful afterword – in Italian and in French – by French semiotician Jacques Fontanille – "Dagli atti di enunciazione ai modi di esistenza" [*From acts of enunciation to modes of existence*] (pp. 43-52 and pp. 53-63). In such afterword, Fontanille clarifies the closeness and the distance between Latour's proposal and the original theory of enunciation, from which Latour draws, in order to track and describe the relations giving way to different modes of existence.

"Piccola filosofia dell'enunciazione" (PFE; Latour 1999) has been initially published in a festschrift dedicated to Paolo Fabbri, semiotician who introduced Latour to semiotics and with whom Latour signed his first science studies article. Fabbri, who is now the director of the Centro Internazionale di Studi Semiotici [International Center for Semiotic Studies] of Urbino, has decided to republish it within the book series of the Center, in order to give visibility to the relevance enunciation had in this first version of Latour's system of "modes of existence" or "regimes of enunciation".

In PFE, Latour indeed explores, for the first time in a general systematic way, the descriptive and comparative possibilities of the enunciational model developed within Greimassian semiotics and already used by Latour in more focused studies of science, technological artifacts, religion and law that have lead to *AIME*.

As Fontanille underlines in the final part of his afterword (p. 49 and p. 60), in between PFE and *AIME*, Latour discovers the French philosopher of modes of existence Etienne Souriau, thus replacing "regimes of enunciation", concept that appears in PFE, with "modes of existence". Consequently, in *AIME* acts of enunciation do not prime anymore and "enunciation", though not absent, is replaced by "instauration", another concept proposed by Souriau. For Fontanille such "ontological turn" is problematic not only because puts semiotics – which has had a key role in Latour's construction – in the shade, but especially because puts into the shade, behind existences, signification processes (semiosis) and the sensitive experience, which, for Fontanille, are directly connected to enunciation intended as production of signification (p. 45 and p. 55).

Since the first formulation of the concept by French linguist Emile Benveniste, theories of enunciation have been elaborated in order to tackle the articulation of the relations between what is in a sentence or in a text and the situation of its production or of its reception. Greimas and his collaborators have proposed a general model of enunciation in order to describe and analyze these relations and their various shiftings, not only for verbal language, but also for gestures, images, artifacts, etc.

Since at least the end of the '80s, Latour has found Greimas' model very useful in order to account for acts of mediations, or "sending" or "delegation" or "passing" (pp. 10 and pp. 26). Such model is articulated in three basic instances:

1. the enunciation, or "pass" for Latour
2. the enunciate, or message or "what is passed", the "quasi-object" in the case of Latour, in which traces of the enunciation can be tracked
3. the relation between an enunciator (3a), the sender, or "who/what passes", and an *enunciatee* (3b), the receiver, "to whom/to which is passed".

This last relation is mediated not so much by the enunciate, the message, like it would be in communication models, but by the enunciation, by the pass.

Besides these instances, the Greimassian model, and hence the Latourian's one, considers two main dynamics: disengagement (shifting-out) and (re)engagement (shifting-in). In the first case something – an enunciate for Greimas, a quasi-object, for Latour – is produced, given existence or "instaurated", by detaching it from the enunciation; in the second case, there is a return to 3), the relation between the enunciator and the *enunciatee*.

Latour, by exploring the combinatorial possibilities of the previous features, tracks and describes nine "regimes of enunciation", which make up the blueprint for the first nine "modes of existence" of the fifteen considered in *AIME* – mind that the names chosen for these first nine "regimes of enunciation" described in PFE are not always the same used for the first nine "modes of existence" described in *AIME*, although their configuration is basically the same.

In PFE, Latour starts by considering "regimes" that do not exploit all the instances: "Reproduction", in which a being (enunciator) passes itself; "Substitution", in which there are only passes without termini, nor quasi-objects; "Omission" or "Belief", in which only the quasi-object takes place, without basically any pass.

Then, Latour considers those "regimes" that present a full-fledged articulation of the three instances: "Technique", in which the quasi-object is completely disengaged from the relation between enunciator and *enunciatee*; "Fiction", in which there is a disengagement of the delegates of the enunciator and the enunciatee and their world in a quasi-object; "Science", in which, alongside the disengagement of "Fiction", a complete reengagement, up to the relations between the enunciator and the *enunciatee*, is required.

Finally, Latour considers those "regimes" which are more concerned with the relations between enunciator and *enunciatee*, the quasi-subjects: "Politics", through which a collective "we" is disengaged and reengaged; "Religion" or "Love", in which continuous reengagements toward the enunciator or the *enunciatee* are carried out, producing an effect of extreme presence; "Law", which is concerned with the multiplication of the marks left by the traces of the enunciation. They allow connecting the quasi-object to various enunciations.

As Fontanille notices (p. 44 and p. 54), Latour's way of working is intrinsically semiotic. Nevertheless, Fontanille criticizes Latour for not being as radical as semiotics, i.e. for not completely discarding metaphysics and Being, something Latour could have done by focusing only on the "the stream of existence" (p. 44 and p. 54, my translation).

However, what Latour does is exactly this. By considering being (in lowercases in *AIME*) always as being-as-other, he tackles it only in "alteration", only as the result of multiple streams of becoming other. Given that, as also Fontanille acknowledges (p. 45 and p. 55, my translation), "alteration" is the only ground needed for semiosis to take place, it seems to me that also the second criticism Fontanille makes, about Latour forgetting signification processes in *AIME*, lapses. Latour, indeed, extends signification processes to all modes of existence, something that he explicitly says in *AIME*: "a sign [as] something that stands in place of something else [...] remains a very general property that could define all types of senses and meanings, even the invisible beings that we have learn to capture in order to sketch the trajectories of being" (Latour 2013, 254).

By reading the dialogue at distance between the two French scholars we can then see various misunderstandings unfolding, which allow assessing the mismatch that today exists between Greimassian semiotics (or, at least, Fontanille's version of it) and Latour's ANT. Such mismatch stems from the different philosophical backgrounds of the two scholars: phenomenology for Fontanille; pragmatism for Latour.

I deem that the value and interest of republishing PFE does not reside so much in the fact that a reference to semiotic categories is more explicit there than in *AIME* or that in PFE Latour is more attentive to meaning processes – which, as we have seen, are relevant also in *AIME*. The value and interest of republishing PFE resides, instead, in the fact that by its conciseness and by the consequent continuous reference to the enunciational model, PFE clearly shows Latour's method of inquiry. The latter is the product of the same descriptive methodology he has always used, which is grounded in semiotics: a set of categories, forming what he calls an "infra-language", that are "first of all negative [...] [and] do not designate what is being mapped, but how it is possible to map" (Latour 2005, 174). Through these categories, in this specific case provided by the Greimassian enunciational model, he is able to map the way in which certain beings circulate by passing from one situation to another. Thus, Latour's classification has nothing substantive and the various "regimes of enunciations" Latour is able to track and describe do not have anything to do with fields or social systems as, for instance, those outlined by Pierre Bourdieu or Niklas Luhmann, although some of their names could allow such analogy. Simplifying, I could say that Latour's one is an operation that takes into account only the syntactic level, leaving the semantic one to the situated enactments of the actors. Therefore, it radically differs from the way Luhmann, for instance, singles out social systems, on the base of semantic dichotomies like legal/illegal or possession/non-possession.

Piccola filosofia dell'enunciazione (con una nota di Jacques Fontanille) is a must-read for those interested in *AIME*, in Latour's thought or in Actor-Network Theory as a material semiotics and it could result stimulating for anyone interested in understanding how to describe and analyze complex relations, given the reflections the book provides on this matter, through both Latour's and Fontanille's contributions.

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Tiago Morera
Science, Technology and the Ageing Society, London and New York, Routledge, 2017, pp. 240

Roberto Lusardi *University of Bergamo*

In this book, Tiago Moreira makes an interesting operation. He takes the concept of ageing – not exactly part of the most popular STS vocabulary – and then breaks it into its parts and analyses the processes connected using the STS gaze. Recalling a metaphor always effective (and dear to the STS world), he "opens the black box" of ageing and the book witnesses what he found.

First, Moreira says that ageing is not just a demographic, medical, or economic concern. It is a repertoire of practices and an institutional setup that the author calls "ageing society". He makes clear his interpretative proposition: that the ageing society "is first and foremost a collective predicament, a swelling uncertainty concerning how to deploy procedures of scientific research and technological innovation in addressing ageing as an issue" (p. 1).

As STS scholars know very well, every collective predicament, every controversy – regardless of whether it concerns political, environmental, or health issues – implies sociotechnical arrangements, expert knowledge, power relations, and economic interests. The demographic data is not secondary, of course. The United Nations set the threshold of population's sustainability to 7% of people being 65 or older in any given country. In Italy, according to the last ISTAT report on the national population, the percentage of people being 65 or older has overcome that mark by far and is at 22%.

The same phenomenon is affecting all the so-called Western nations, albeit in different percentages. This means that the demand for healthcare services and funding of health insurance is increasing, as are the pressures on systems of formal care and on processes of informal care within families and communities. Finally, the demographic trend affects the political and cultural attitudes of society, which tend to become more conservative.

Moreira proposes not to analyse only demographic data, but also to examine the ways in which we understand and manage the ageing process in society and how they shape our collective life (Ch. 1). His approach is derived from Foucault in that he offers a genealogical history of the present, focusing on the link between structures, practices and contingencies. He proposes to understand the ageing society as an epistemic assemblage, in which making procedures and institutions, techniques, and technologies shape how we see our society through a demographic prism. The ANT apparatus stands out in the book's toolbox: Michel Callon, Bruno Latour, John Law, Annemarie Mol, among others, discuss with gerontologists, demographers, epidemiologists, cultural geographers and economists (Ch. 2).

The author states that the ageing society is challenging the epistemic infrastructure of the liberal welfare state and the system of expert knowledge on which it relies. To demonstrate these transformations, Moreira invites the reader to rethink the relationship among birth, death, and migration. Races and migrations are indispensable concepts for understanding the constitution of the ageing society despite the fact that they have not until recently taken into account the management of demographic ageing (Ch. 4).

This omission seems to rely on a precise bio-political orientation that contrasts migratory flows on one hand and medical technologies and health services on the other as resources to mitigate some of the economic effects of ageing populations (Ch. 5). Due to this orientation, widespread in the 1980s and 1990s, "the relationship between health and longevity has become central to the problem of population because of the fact that the problem of population decline is the disqualified immigration and the fertility as a solution to the problem of demographic ageing" (p. 71).

The author investigates the same concept of chronological age – by the number of years lived since birth – which we use to measure a person's functional capacity or health. Moreira discusses how the diffusion of this analytical tool is linked to the requirements of precision and classification inherent in the information requisites of modern state bureaucracies and administrations. The author shows how this model is challenged by emerging epistemic and normative uncertainty about chronological age as a variable and marker for social and political rights and duties. At present, no alternative model has been imposed to replace chronological age with its age-specific norms, values, and expectations although its solidity and reliability has been questioned widely.

Chronological age is at the base of the Baltimore Longitudinal Study of Aging (BLSA), a massive U.S. public programme of investigation on ageing that has been funded from 1958 to the present day (Ch. 6). Moreira reconstructs the history of this programme and its epistemic repertoires to demonstrate how epistemic and methodological procedures shape the ageing society: "Ageing is an individualized process [that] became entangled with a set of methodological procedures and practices encased in the longitudinal approach" (p. 117).

He then introduces a more recent key concept: functional age (Ch. 7). This consists of tools and instruments (e.g. the Work Ability Index) that measure and manage individual functional abilities and indicate the roles or tasks a person may be involved in. For Moreira, this concept represents the relation between work and technology and the ageing society, and it aims to "maximise older people's participation in the economy by identifying unused capacities and opportunities to employ them" (p. 120). Tracing the assemblage around the concept, Moreira unveils the epistemic tensions that it hides.

Another interesting object analysed is the Instrumental Activities of Daily Living Scale, a tool used in the assessment and planning of older people's care (Ch. 8). Moreira suggests that its relevance relies on the expectation of aligning aging-in-place policies with active ageing instruments. Following the genesis of this tool and analysing its contexts of use – that require the process of rational decomposition of daily life activities such as cooking, housekeeping, laundry, etc. – Moreira describes how the reliability of tools like this is constantly challenged by situated practices of customization of ageing-in-place tools to individual needs.

Finally, the author's last efforts lead to an analysis of the most recent epistemic scaffolding named "biomedicalization of ageing". Using Alzheimer's disease as a case study, Moreira emphasizes how this new platform is based on the frail alliance among biogerontology, mainstream medicine, and anti-aging movements (Ch. 9).

To conclude, this is a very interesting book, which proposes an unprecedented reading of contemporary society and the theme of the ageing population. It is not easy to read because the argumentation is complex; very articulate. It integrates theories, analytical tools, and empirical materials from different scientific fields and epistemic domains. Nevertheless, given the relevance of the topic and the innovative approach, it is certainly worth it.

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Trebor Scholz and Nathan Schneider (eds.)
Ours to Hack and to Own. The Rise of Platform Cooperativism, a New Vision for the Future of Work and a Fairer Internet, New York and London, OR Books, 2016, pp. 252

Giacomo Poderi *University of Bergen*

According to the editors, *Ours to Hack and to Own* is a "guidebook for a fairer kind of Internet" built upon two pillars. First, democratic governance and democratic ownership are the fundamental aspects of platform cooperativism and, ultimately, the core topic of the book. In Scholz's words: "The term 'platform' refers to places where we hang out, work, tinker, and generate value after we switch on our phones and computers. The 'cooperativism' part is about an ownership model for labor and logistics platforms or on-line marketplaces that replaces the likes of Uber with cooperatives, communities, cities, or inventive unions" (p. 24). Second, the book tries to foster a (lengthy, complex and messy) process, rather than advocating technological solutionism. Basically, the collection provides a snapshot of an emerging phenomenon and, at the same time, supports the efforts of co-constructing it, by promoting and vouching for it. As Scholz and Shneider clarify, the book is a direct follow-up of their meeting during a two-day event about platform cooperativism, where they both participated to present their works: "Platform Cooperativism: The Internet, Ownership, Democracy" (New York, November 2015). Coming from two separated, yet converging, intellectual trajectories – Scholz main focus is on platform cooperativism (Scholz 2016), while Schneider's one is on shared ownership and governance (Schneider 2014) – the two embarked in this book project which resulted in a rich collection of short essays that, in my opinion, reads more like a manifesto for platform cooperativism than a guidebook for it.

In a historical moment when the imagined future of the "sharing economy", together with its promises, has been progressively unmasked and replaced by the dominant orders of so called technocapitalism (Suarez-Villa 2001), gig economy (Todolí-Signes 2017) or platform capitalism, platform cooperativism emerges as a noteworthy alternative. For STS scholars, who have always been interested in the politics of technology (Winner 1980) and the infrastructuring processes that shape and (re)configure socio-technical power networks (Mongili and Pellegrino 2014), platform cooperativism can represent a relevant occasion to look at these themes and at how they play out through Internet from a perspective which we might call of "inverse infrastructuring" (Egyedi and Mehos 2012). In particular, this anthology can act as a thought-provoking work supporting STS scholars to get closer to the theme, and looking at it from the vantage point of those ones who are actually shaping it. The book does not use STS vocabulary or constructs and, strictly speaking, it is not an academic work. However, it does address the topic by deconstructing and addressing it at many different levels. The lead title – *Ours to Hack and to Own* – is emblematic to this regard. Aligned with hackers' practices the book provides scaffolding tools for creating, spreading and supporting platform cooperativism, by including chapters as design guidelines for its technical protocols, its social and cultural aspects, as well as the economic, legal and organizational ones linked to the institution of cooperatives. Central idea threading among the chapters is always the preservation of the ownership of all the value aspects – not limited to the economic ones – emerging from a platform cooperative. It is in this light that, in my opinion, "hack" comes to hint at the original hackers' culture and suggests platform cooperativism as "an hack to the system of platform capitalism".

Despite the number of topics dealt by the many small chapters can sometimes feel bewilder, I was positively surprised by how many of these chapters implicitly talk to each other and manage to square the circle for the materialization and sustainability of platform cooperativism, without betraying its founding principles. The followings are two valuable examples.

First, in her chapter, *Blockhains and Their Pitfall*, Rachel O'Dwyer raises a warning about the diffusion of the distributed database technology, known as blockhain. Mainly used for handling and accounting digital currencies and their transactions (e.g. BitCoin), blockhain is being adopted as a technological fix in other domains beyond the original one. However, O'Dwyer points out that "blockchain is what we call a 'trustless architecture'. It *stands in* for trust in the absence of more traditional mechanisms like social networks and co-location" (p. 230). She warns us that complex and time-consuming processes cannot be replaced by technical solutions and that similar technical tools must always be accompanied by broader considerations. In *From Open Access to Digital Commons*, David Bollier takes stock of the warning when proposing blockchain technology as means to shift from open platforms – where access is free, but value is exploited by platform owners and not users – to communal ownership and management of digital artifacts and their related values. Here, the case is made for seeing blockchain as a complementary tool to a complex social, cultural, and technological reconfiguration process. Second, in *The realism of Cooperativism*, Yochai Benkler elaborates on four fundamental challenges which platform cooperativism needs to deal with in order to emerge and consolidate, and provides indications on how these might be tackled. The most troubling one relates to the means of long-term sustainability for platform cooperatives: these usually build on the organizing practices of peer production, although this typically relates to volunteer contributions by people who already have other means of subsistence. Conceptually, platform cooperativism could rely on commons governance (Ostrom 1990), but it would still need practical means to break the ties with capitalist investments in the long term. *Money is the Root of all Platforms*, by Brendan Martin, deals with this issue: he identifies in the private and market oriented investments a constant danger for platform cooperatives. A way out is to see finance and platform financing as a platform: turning finance into a (pervasive) platform cooperative.

Ours to Hack and to Own includes contributions by activists, hackers, entrepreneurs, policy makers and researchers who are actively engaged with the core topic of the book. Each chapter begins by introducing and defining a challenge, approach or key aspect of platform cooperativism and, in a few pages (pp. 4-5), provides a direct answer to strengthen, pursue or solve it. Although for some chapters the feeling of remaining too much on the surface it is stronger than in others, I personally appreciated the assertive tone, and the clear and focused messages of each chapters, regardless of the limited available space for problematizing issues and dwelling into the details. The book is structured around four main parts ("Something to Say Yes to"; "Platform Capitalism"; "An Internet of Our Own"; "Conditions of Possibility"). The first one serves an introductory scope: the conceptual bases that define "platform cooperativism" and clarify its foundations are captured here. The second sets of essays collects critical reflections on platform capitalism that highlight the challenges and opportunities in the existing on-line (or sharing) economy. With fifteen and twelve chapters each, plus two showcase sections, the third and fourth parts of the book are the most substantial ones. The former addresses issues concerning the practical design and creation of on-line platforms cooperatives. The latter takes a broader perspective and deals with the ecosystem that is needed to widely support a shared, democratic ownership and governance of Internet. The showcase sections include more than a dozen of one-page sheets each. These describe noteworthy examples of running platform coops and ongoing projects that support platform coops from an ecosystem point of view. It is a pity that the book ends without a bibliography or an end-notes section, and only with a minimalist "Further Resources" section.

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