The Praxis and Politics of Building Urban Dashboards

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Abstract

This paper critically reflects on the building of the Dublin Dashboard -- a website that provides citizens, planners, policy makers and companies with an extensive set of data and interactive visualizations about Dublin City, including real-time information -- from the perspective of critical data studies. The analysis draws upon participant observation, ethnography, and an archive of correspondence, to unpack the building of the Dashboard and the emergent politics of data and design. Our findings reveal four main observations. First, a dashboard is a complex socio-technical assemblage of actors and actants that work materially and discursively within a set of social and economic constraints, existing technologies and systems, and power geometries to assemble, produce and maintain the website. Second, the production and maintenance of a dashboard unfolds contextually, contingently and relationally through transduction. Third, the praxis and politics of creating a dashboard has wider recursive effects: just as building the dashboard was shaped by the wider institutional landscape, producing the system inflected that landscape. Fourth, the data, configuration, tools, and modes of presentation of a dashboard produce a particularised set of spatial knowledges about the city. We conclude that rather than frame dashboard development in purely technical terms, it is important to openly recognize their contested and negotiated politics and praxis.

Key words: assemblage, dashboard, data, Dublin, politics, smart city

Introduction

There is a long history of cities generating data about their form and activities and distilling such data into information and knowledge to manage and control urban operations and guide and evaluate public policy. Over the past fifty years, much of these data have been digital in nature and the increasing power of computation has been used to process, analyze and store them, for example, through information management systems, spreadsheets, stats packages, and geographic information systems. More recently, there has been a step change in the production of urban data through the embedding of computation into the fabric and infrastructure of cities -- the creation of 'everyware' (Greenfield 2006) -- to produce a new form of data-rich and data-driven networked urbanism (Shepard 2011; Kitchin and Dodge 2011; Townsend 2013). Here, a variety of devices, cameras, transponders, actuators and sensors, each producing streams of big data that can be processed and responded to in real-time, are used to augment and mediate the operation and governance of urban systems (Kitchin 2014a). These machine-readable and controllable environments form a critical part of the present drive to create a new form of urbanism, what is widely termed 'smart cities' (Hollands 2008; Townsend 2013).

The introduction of 'smart cities' into the urban and popular lexicon is a relatively recent phenomenon, popularised through an aggressive IBM marketing campaign started in 2010, accompanied by the efforts of several other large multinationals looking to generate a new city market for their technologies and services, and the place marketing of a number of cities seeking to re-brand and re-position themselves in the global city hierarchy. It is, however, the latest stage in the evolution of networked urbanism that has been developing rapidly since the late 1980s (Graham and Marvin 2001) that has variously been termed 'wired cities' (Dutton *et al*., 1987), 'cyber cities' (Graham and Marvin 1999), 'digital cities' (Ishida and Isbister 2000), 'intelligent cities' (Komninos 2002), and 'sentient cities' (Shepard 2011). Whilst the definition of smart cities is somewhat open and contested within the literature and amongst stakeholders, smart city advocates generally agree that a smart city is one that strategically uses ICT and associated big data and data analytics to improve existing city services and create new services, engage citizens, foster sustainability and resilience, solve urban issues, and stimulate innovation and grow the local economy.

In such a vision, the generation and analysis of contextual and actionable data is a central pillar, with the city becoming increasingly knowable and controllable in new dynamic ways. As such, accompanying the rise of networked urbanism has been an increased emphasis on harvesting, collating, processing and analyzing urban data across all aspects of

city life and urban systems. Correspondingly, since the early 1990s there has been a proliferation of urban indicator projects utilising administrative and official statistical data, and urban control rooms of varying kinds (e.g., security, transport, utilities) capable of handling so-called big data (generated in real time, exhaustive to a system, and large in volume; Kitchin 2014a). Increasingly, these data are being centralised into single city operating systems and facilities, collapsing the walls between data silos and enabling a more holistic and integrated view of city services and infrastructures that can guide daily operations and long term planning and policy formulation. The archetypal example of such a system is the Centro De Operacoes Prefeitura Do Rio in Rio de Janeiro, Brazil, a data-driven city operations centre that pulls together into a single location real-time data streams from thirty agencies, 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. These data are overseen and processed by a staff of 180 data operatives working across three shifts to provide twenty four hour analyses and services.

A key approach to making sense of such data has been a new suite of visual analytics that are dynamic, interactive, inter-linked, and use traditional graphs, charts and maps, as well as more innovative visual presentations such as gauges, 3D models and augmented landscape images made possible by advanced computer graphics (Keim *et al*., 2010). Unsurprisingly then, a key feature of urban control rooms are banks of computer screens displaying visualized data. Such data are often presented and navigated through a dashboard interface. Dashboards provide a visual means to organize and interact with data, enabling users to drill down into data sets, filter out uninteresting data, select an item or group of data and retrieve details, view relationships among items, extract sub-collections, and to overlay and interconnect disparate data, enabling summary-to-detail exploration within a single visualisation system (Dubriwny and Rivards 2004; Few 2006). Dashboards act as cognitive tools that improve the user's 'span of control' over a large repository of voluminous, varied and quickly transitioning data (Brath and Peters 2004) and enable a user to explore the characteristics and structure of datasets and interpret trends without the need for specialist analytics skills (the systems are point and click and require no knowledge of how to produce such graphics). They can also facilitate the exporting of visualisations for use in documents, or sharing via social media, or accessing the underlying data for importing into other analytical packages. With the recent drive towards producing open data, some of the data feeding urban control rooms and city dashboards, as well as wider administrative and

statistical data, are becoming freely available for wider deployment. As such, other parties are able to use the data to conduct their own analyses, build city apps, and create their own urban dashboards. And in some cases, the city itself is publicly sharing data and visualizations via an open dashboard.

The power and utility of urban dashboards is their claim to show in detail and often in real-time the state of play of cities. As Kitchin *et al*. (2015: 12-13) put it, urban dashboards purport to "enable us to know the city *as it actually is* through objective, trustworthy, factual data that can be statistically analyzed and visualised to reveal patterns and trends and to assess how it is performing vis-a-vis other places. [They supply] a rational, neutral, comprehensive and commonsensical evidential basis for monitoring and evaluating the effectiveness of urban services and policy, to develop new interventions, and to learn and manage through measurement." In so doing, dashboards facilitate the illusion that it is possible to "picture the totality of the urban domain", to translate the messiness and complexities of cities into rational, detailed, systematic, ordered forms of knowledge (Mattern 2014). In other words, they provide a powerful realist epistemology for monitoring and understanding cities, underpinned by an instrumental rationality in which 'hard facts' trump other kinds of knowledge and provide the basis for formulating solutions to urban issues (Kitchin *et al*. 2015; Mattern 2014; 2015). As such, they seemingly provide a neutral and value-free medium through which to govern and plan a city. Indeed, dashboard initiatives have become central to the regimes of urban governance in many cities, either providing a means to assess, guide and resource daily operational practices across public services and/or provide wider contextual information that shapes policy formulation and planning (Edwards and Thomas 2005; Miller 2005; Gullino 2009; Kitchin *et al*. 2015).

In contrast to such thinking and framing, the realist epistemology and instrumental rationality of urban dashboards has been critiqued from a number of perspectives. First, dashboards, it is contended, are not simply neutral, technical, commonsensical tools, but rather are framed socially, political, ethically, philosophically in terms of their form, selection of data, modes of display and analysis, and deployment (Kitchin *et al*. 2015). The data dashboards process and present are the product of the ideas, instruments, practices, contexts, knowledges and systems used to generate, process and analyze them. Urban data are framed by and situated within data assemblages that profoundly shapes their production, distribution, and use (Kitchin 2014b; see Table 1). As a data assemblage a dashboard is a complex socio-technical system, composed of many apparatuses and elements that are thoroughly entwined

and shape each other through a contingent and complex web of multifaceted relations and condition how a dashboard is formulated, developed, administered, deployed, and used.

Table 1: The apparatus and elements of a data assemblage

Apparatus	Elements
Systems of thought	Modes of thinking, philosophies, theories, models, ideologies, rationalities, etc.
Forms of knowledge	Research texts, manuals, magazines, websites, experience, word of mouth, chat forums, etc.
Finance	Business models, investment, venture capital, grants, philanthropy, profit, etc.
Political economy	Policy, tax regimes, incentive instruments, public and political opinion, etc.
Governmentalities and legalities	Data standards, file formats, system requirements, protocols, regulations, laws, licensing, intellectual property regimes, ethical considerations, etc.
Materialities and infrastructures	Paper/pens, computers, digital devices, sensors, scanners, databases, networks, servers, buildings, etc.
Practices	Techniques, ways of doing, learned behaviours, scientific conventions, etc.
Organisations and institutions	Archives, corporations, consultants, manufacturers, retailers, government agencies, universities, conferences, clubs and societies, committees and boards, communities of practice, etc.
Subjectivities and communities	Of data producers, experts, curators, managers, analysts, scientists, politicians, users, citizens, etc.
Places	Labs, offices, field sites, data centres, server farms, business parks, etc, and their agglomerations
Marketplace	For data, its derivatives (e.g., text, tables, graphs, maps), analysts, analytic software, interpretations, etc.

Source: Kitchin (2014b: 25)

Second, dashboards act as translators and engines rather than mirrors, deploying a communicative protocol that frames how data are visualised and thus what the user can see and engage with, and what questions can be asked and how the answers are displayed (Franceschini et al. 2007; Galloway 2012; Mattern 2014, 2015). Dashboards do not simply represent urban phenomena, but generate new visions and understandings of the city; they actively produce meaning and do work in the world. Moreover, they deploy a global scopic system of generalized visual forms that occludes certain forms of knowledge and keep black-boxed the algorithms, databases, software and design decisions that shape the interface's look-and-feel and operation (Drucker 2013). In order words, the dashboard interface is not a neutral, value-free medium, but rather profoundly influences its message and use.

Third, dashboards are reductive, atomizing complex, contingent relationships into relatively simple visualized measures that obscures the multidimensional nature of cities. Moreover, they decontextualize a city from its history, its political economy, the wider set of

social, economic and environmental relations, and its wider interconnections and interdependencies that stretches out over space and time (Craglia *et al*. 2004; Mori and Christodoulou 2012). In so doing, dashboards suggest that a city is simply the sum of its measures and be can be known, planned and controlled through data processes and algorithms alone; that a city is simply a system that acts in a 'rational, mechanical, linear and hierarchical' way and 'can be steered and controlled' much like a car is through its dashboard (Block and Van Assche 2010: 3). Instead, cities are complex, open and contested systems, full of culture, politics, inequalities, and messy social realities that cannot simply be pushed, pulled and directed through data-informed levers.

Taken together, these critiques contend that far from being neutral, objective, apolitical communication tools, dashboards are inherently active and ideological. They express a particular vision of cities and urban governance; a normative notion about what should be measured, what should be asked, and what should be revealed; and they have normative effect, shaping decision-making and behaviour (Kitchin *et al*. 2015).

In this paper, we explore in depth the first of these critiques by examining the contention that a dashboard constitutes a data assemblage that unfolds in contextual, contingent and iterative ways through a detailed case study of the development of the Dublin Dashboard, an extensive, open, analytical dashboard launched in September 2014. The Dublin Dashboard is a website (http://www.dublindashboard.ie) that provides citizens, planners, policy makers and companies with an extensive set of data and interactive data visualizations about Dublin City, including real-time information, indicator trends, inter and intra-urban benchmarking, interactive maps, the location of services, a means to directly report issues to city authorities, and links to city apps. The data used in the Dashboard is open and available for others to build their own apps.

Drawing on the call to chart and unpack data assemblages within the nascent field of critical data studies (Dalton and Thatcher 2014; Kitchin and Lauriault 2014), we trace the constituent apparatus and elements of the Dublin Dashboard and the praxis and politics involved in its unfolding development from initial conception through to its launch using a combination of ethnography and participant observation -- two of the authors were lead developers and the third was employed as an ethnographer on the project for six months, attending internal development meetings and external meetings with the local authority stakeholder and two companies. Whilst one or both of the two developers attended all internal meetings (c. 20 mostly informal meetings arranged on an ad hoc basis) and external meetings (14 formally arranged meetings with stakeholders and interested parties), the

ethnographer attended seven external meetings and six internal meetings and conducted an interview with one of the lead developers. In all cases, the ethnographer acted as an observer at meetings, taking notes with regards to the conversations and decisions taken, with just one internal meeting and the interview being voice recorded. In addition, the whole of the launch event was video recorded and all email exchanges between participants were archived. Drawing on this material we document the contingent unfolding of the Dublin Dashboard and the contested and negotiated politics of smart city initiatives. We start by telling the story of how the dashboard was developed, before examining and unpacking the dashboard as a socio-technical assemblage.

Building the Dublin Dashboard

The Dublin Dashboard project was initially conceived as a response to a relatively unusual funding opportunity. In November 2012, the European Research Council announced that it would be funding 'The Programmable City' project (http://www.maynoothuniversity.ie/progcity/) through a five year Advanced Investigator Award, to start June 1st 2013. Shortly after notification of the award, the principal investigator was approached by Science Foundation Ireland about the possibility of applying for a supplemental support grant for ERC funded projects. Whilst the Programmable City project was granted through a social science and humanities panel of the ERC, and essentially applied a software studies/critical data studies approach to understanding the development, rollout and implications of smart city technologies, it was made clear that SFI would consider funding additional smart cities research if it were more technically (STEM) orientated. The most pragmatic and logical way to apply for this supplemental grant was to leverage off and extend existing geospatial visualization work already being overseen by the principal investigator, seeking to create a smart city technology as a way of further understanding the praxis and politics of such technologies.

The All-Island Research Observatory (AIRO; http://www.airo.ie) was initiated in 2005 (initially titled the Cross-Border Regional Research Observatory) and provides open access, online interactive graphs and maps of public administration and official statistics data across a broad range of domains (e.g., economy, population, housing, environment, transport, health, etc) for both the Republic of Ireland and Northern Ireland, as well as data management and spatial analysis research services and training courses in analyzing and interpreting spatial data. AIRO has undertaken contract work for the majority of local and regional authorities and government departments in Ireland, as well for a number of state

agencies and public sector bodies in Northern Ireland, and was the official data visualisation partner for the 2011 Irish Census. It has also received Irish and EU grant funding from the Higher Education Authority, ESPON and Interreg, and has worked with a number of private companies.

The initial idea for the supplemental grant was to extend the kinds of work that AIRO undertook to include real-time data (some of which we knew was available for the city through Dublinked, a project hosted elsewhere within the university which makes available as open data various operational and real-time datasets from the four local authorities in Dublin with the aim of fostering innovation), combining them with new indicator and city benchmarking visualisations, to build a city dashboard for Dublin. In effect, the starting vision was to see if we could create a dashboard that merged elements of the CASA London city dashboard (real-time data; http://citydashboard.org/london/) with the London Dashboard (public administration and statistical data; http://data.london.gov.uk/london-dashboard). Through the dashboard it was envisaged that the following questions might be answered: how well is Dublin performing? what's happening in the city right now? how does Dublin compare to other places? Given that most of the data required was in the public domain, our track record of producing extensive data visualisation tools about places independent of their governance, and for the sake of expediency, none of the four Dublin local authorities were approached whilst formulating the project proposal. The application for the supplemental grant was applied for in July 2013 and awarded late September, with a start date of 1st October 2013. A two year postdoctoral research post to build the dashboard was advertised early October, with interviews in late October, and the researcher started work on the project in November. Whilst the researcher initially worked full-time on the post, due to their own application for funding being successful, they swapped to a half-time appointment in April 2014.

The first internal team meeting took place in early November 2013 and set out a plan of action required to build the dashboard. This included scoping out more fully the parameters, scope and principles of the envisaged dashboard, identifying desirable datasets and their necessary characteristics (generated annually or sub-annually; at the scale of Dublin or more fine-grained), discussing the organisation of the site and the look and feel of the interface and the potential software to be used (including whether to use propriety or open source), sketching out a basic strategy and timeline of development, and setting out what research needed to be undertaken in the short term. Our initial basic underlying principles for the site were that: there would be no closed elements with all of the visualizations on the site

are accessible to everyone; all of the data used on the site would be open in nature, enabling others to access them and build their own apps; the site would be very easy to use, with users requiring no mapping or graphing skills; and the site would be interactive allowing users to explore the data. The initial research would consist of two main tasks. First, conducting a detailed data audit of the city, identifying what datasets existed, their spatial and temporal characteristics, who held them, if they were public domain, and the data format and standards. Our hunt for suitable indicator datasets was guided by previous audit work conducted by AIRO, the London Dashboard, and the 100 key indicators detailed in the then forthcoming ISO 37120 standard for city indicators (http://www.cityindicators.org). Second, exploring other city dashboards, and dashboards and open data sites more generally.

The first month's work consisted of this research, plus producing an initial mock-up of the site. Our intention was to build a working prototype and then to approach Dublin City Council (DCC) with a view to forming a working relationship to seek additional datasets and institutional stakeholder support. However, in mid-December, the Office of International Relations and Research Office (OIRRO) in DCC informed AIRO that it was in the process of formulating a tender for the development of a 'Data Visualisation of a Dublin Indicator Database' that appeared to overlap significantly with some of the work we were undertaking for our prototype dashboard. Five days later we had our first meeting with a junior member of the OIRRO in DCC where we set out what we were doing and he detailed what DCC were envisaging, and there was a general exchange of knowledge and ideas. It was agreed that we would continue to develop the dashboard and DCC would supply a spreadsheet of data they were hoping to include in their data visualization suite for inclusion in the dashboard. We would also explore the possibility of sourcing data for the 37 indicators across 10 themes identified as desirable indicators by DCC in their recent sustainability report (Dublin City Council 2012). We would then meet again in the new year for further discussion.

During January the data audit was completed. This research had consisted of an extensive trawl of local authority, government department and state agency websites, and liaison with stakeholder contacts and members of the open data community to compile a database of Dublin-related data. Where the data was publicly available it was downloaded and examined as to its suitability for inclusion in the dashboard based on its spatial and temporal granularity and quality. This often involved extensive discussion and debate about data veracity and lineage and possible proxies when the required data was missing or not published with sufficient granularity. We also examined the data supplied to us by DCC and sought to source the data for the desired 37 indicators. From our experience of handling Irish

data we knew that sourcing indicator data at a sufficient granularity might be difficult (especially given that data are generally not georeferenced due to the lack of postcodes), nonetheless it soon became apparent that sourcing suitable data for some indicator themes, such as education, health and demography was impossible beyond the five yearly census data. In the case of the first two, the data existed but was not in the public domain and was unlikely to become so without political pressure. Of the 37 indicators desired by DCC only 10 were available at a Dublin city or finer scale on an annual/sub-annual basis (one of which has subsequently become unavailable due to privatisation (water consumption)). In general, we found that data generated by national agencies were more likely to be available and suitable than those generated by local government, though there was variation across agencies. In some cases there was a significant time lag on data publication (e.g., 2012 data being published in 2014). Often data could only be sourced through annual reports as the data was not published for reuse, meaning that the data had to cut and pasted from a PDF into a database. Only in the case of the real-time data was the data machine-readable through an API (although in 2015 the Central Statistics Office made its Statbank machine-readable). Work also continued on the scope and design of the dashboard, with the visual interface being worked through several iterations, and the organisation of the material on the website being reconfigured, to a large part guided by the availability of data. In the case of real-time data, initial mock-ups that displayed the data via interactive maps were created.

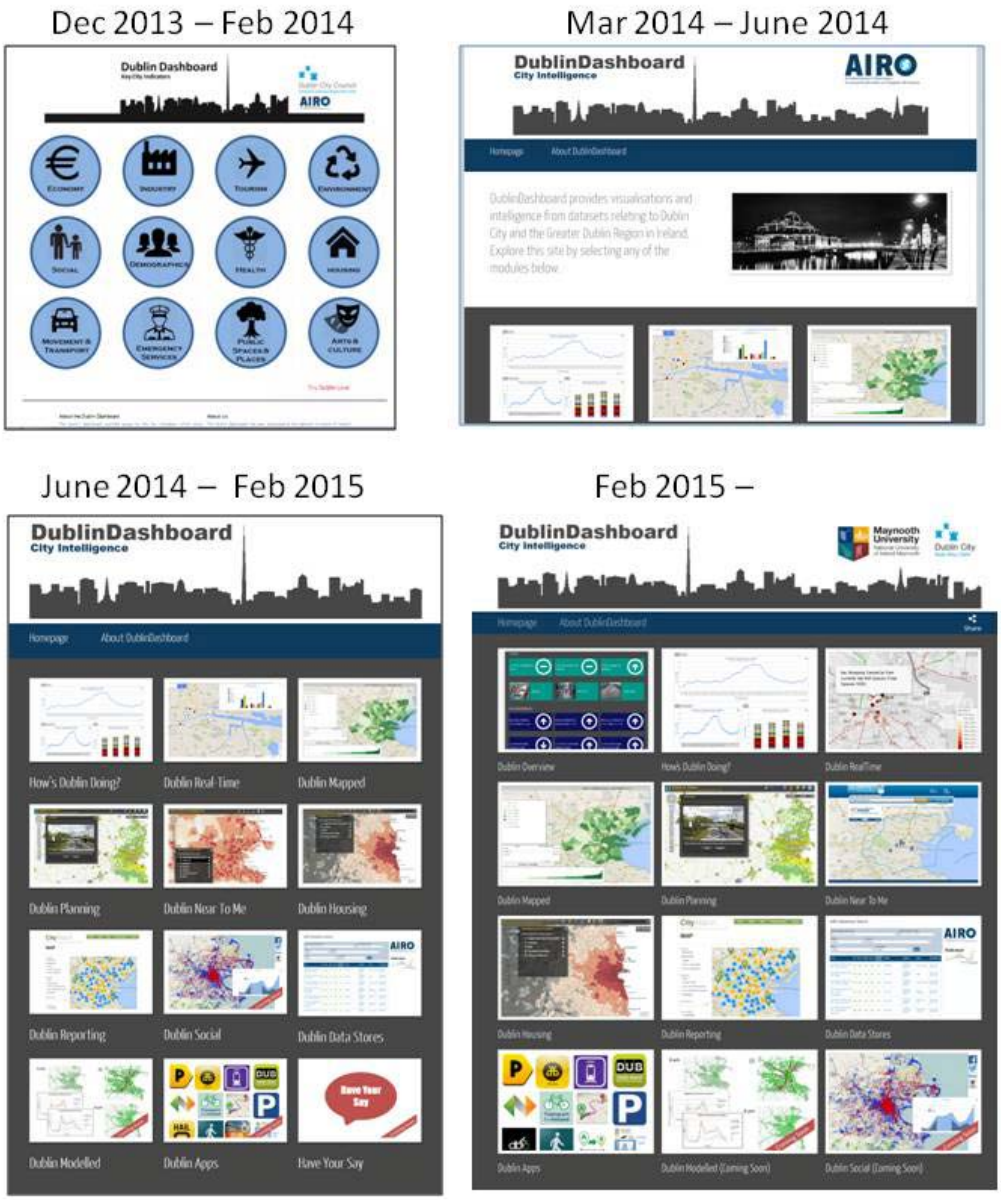
In mid-February 2014 we held two meetings with OIRRO, one consisting of a phone conversation with its head, the other with our initial contact and his colleague. The first consisted of providing a general overview of what we were doing and how we anticipated the project developing. An invitation was also extended to speak about DCC and its smart city initiatives at the launch of the Programmable City project at the end of March. The second meeting consisted of a detailed discussion of data sources and indicators and a demonstration of the site as was. The outcome of the meetings was that DCC became a partner in the Dublin Dashboard project, although it would only contribute resources in-kind through occasional staff time with the key funding source being the SFI supplemental grant, and it was agreed that the logos of both the university and DCC, as well as the funders, would be displayed on the dashboard. To date, no contract has been signed with DCC or any other potential stakeholder, nor has there been a formal discussion as to the maintenance and on-going development and delivery of the Dublin Dashboard post November 2016. It was also agreed that the initial Dublin Dashboard design would be presented at the launch of the Programmable City project.

A week after the two meetings with DCC, the lead developers swapped email and we held an internal meeting in which it was decided change quite markedly the scope of the dashboard. Instead of the dashboard only conveying selected indicator, benchmarking and real-time data, the site would seek to incorporate as much data about the city as available, leveraging mapping and graphing modules in AIRO and linking to websites and apps developed by others. In this vision, the dashboard would become a mix of data visualisation site and portal, and would include a set of interactive mapping modules displaying census, housing, crime, welfare, planning and land use data, as well as the location and accessibility of services, and links to city benchmarking sites, city apps, data stores, and crowdsourced reporting of city issues. In essence, the dashboard would allow additional questions to be asked: where are the nearest facilities/services to me? what are the spatial patterns of different phenomena? what are the future development plans for the city? how do I report issues about the city? how can I freely access data about the city? Over time, it was envisaged that interactive maps of social media activity and a modelling module that would enable simulation and predictive profiling of city development might be added. The initial working name for the site was 'MyDublin', though this was later dropped in favour of 'Dublin Dashboard', in the main because the 'mydublin.ie' domain name was unavailable (we later discovered it was owned by DCC) (see Figure 1).

Whilst this new vision was much more ambitious, a good chunk of the work had already been done by AIRO and could be repurposed, and linking out to other sites was straightforward. Over the next three weeks this new scope was implemented, with the website being quite markedly changed. This also included re-jigging the indicator themes from twelve to six, principally because of the lack of suitable data for some themes. Guiding these developments were two new principles: as much data as possible, regardless of source or type, would be made available through the site; and existing resources and apps would be used if they did a good job to remove duplication of effort. The newly conceived site, including a mock-up of branding, was presented to OIRRO at a meeting at DCC five days before the Programmable City launch. The reception was very positive, with few requests for changes or suggestions for project development. Indeed, in contrast to other projects we have conducted with stakeholders, there was little attempt by DCC to overtly steer or control the direction of the dashboard, and contrary to normal practice we actively sought parameters and boundaries, in part because we did not want to build out the full system to then encounter problems later due to lack of early guidance. There was a discussion at this meeting about including targets against indicators to indicate performance, but in the absence of already

established set targets and the political nature of us imposing targets they were not pursued. Similarly, a DCC suggestion for including key indicator trends on an opening page at our discretion was dropped as the selection as to what indicators to include is a political decision given it creates a particular narrative (we could, for example, decide to fill the screen with negative trends). The same beta site was then displayed and discussed at the Programmable City project launch.

Figure 1: Evolution of the Dublin Dashboard



In the weeks that followed we had internal meetings to continue to iteratively plan and build the dashboard site. This included on-going decision making with respect to data set inclusion, reworking of site organization, playing with the look and feel of the interface, email and phone exchanges with data holders, liaising with DCC offices to try and source data sets, or hunting through websites to discover data or interesting existing data visualisation projects for the city, and purchasing the website domain. Although the project was now officially badged as a DCC initiative, the authority is a large organisation consisting of many different departments that effectively work as silos, and it was often quite difficult to locate data or find the right contact person. In general, once identified individuals and departments were open to providing data but lacked resources to make data available regularly or to automate the process by creating an API. Only in a couple of cases were departments reluctant to make data available for other reasons (e.g., data protection, data security, caution about exposing data to scrutiny). To try and overcome this issue we created a priority list for unlocking real-time data and liaised with the DCC Dublinked manager, who in turn liaised with other DCC staff. We also worked with AIRO team members to set up data visualizations so that they could be placed into iframes on the Dublin Dashboard site (whilst remaining on the AIRO servers).

At the beginning of May 2014 at private meetings we presented the Dashboard to the Minister of Innovation, Science and Technology of Jalisco, Mexico who was visiting Dublin to attend a Mexico-Dublin Business Conference, and also Sean Sherlock TD, the Irish Minister for Research and Innovation who was interested in finding out more about smart cities research in Ireland. Later in the month we met two staff from a large multinational who were interested in whether they might be able to contribute technology or expertise to the project, who returned a month later to enquire about using the Dashboard as a springboard for an internal hackathon (which was declined because it would take place before the official launch and they were interested in seeking publicity). In early June we also met with another multinational who had signed a MoU with DCC to roll out a widescale sensor network across the city to discuss the project generally and the feeding of the sensor data into the dashboard more specifically.

Also in early June we had two back-to-back meetings in DCC. The first was with OIRRO and consisted of a review of on-going work on the dashboard. The second was with DCC Dublinked manager and the DCC smart city coordinator who worked in the Chief Executive's Office and consisted of a general overview and discussion about the dashboard. It was from this point on that we started to liaise with both OIRRO and the CEO's office and

we became more fully aware of the transition occurring within the organisation as smart city initiatives started to become more centrally coordinated and the associated internal politics associated with this shift. We continued this joint liaison up until the launch, after which we have dealt almost exclusively with the CEO's office and with Dublinked. Throughout June and July we also drafted our first paper related to the project, which was submitted to a journal at the end of July.

By the end of July we were confident that we were nearing the point at which we could launch a comprehensive, although not fully functioning, dashboard, with eight out of the 12 modules operational, containing thousands of interactive graphs and maps. Our preference was to seek an early launch to try and leverage additional data sets and working relationships with other data providers. We also knew that two of the remaining domains (social media analysis and modelling) were large tasks that required additional funding and would not be operational for some time. In mid-August we held an internal meeting, inviting colleagues not associated with the project to provide feedback on the look and feel and operation of the dashboard. A fairly extensive conversation unfolded as different elements of the site were queried and different solutions discussed, and the observations were used to tweak the design accordingly. A few days later we had back-to-back meetings in DCC. The first meeting was to review the site and discuss a possible launch date and the format of the launch, possible speakers, and media coverage (RTE1, the national broadcaster had already expressed an interest in covering on both radio and television news based on the preliminary demo at the Programmable City launch). It was at this meeting that the inclusion of certain indicators that did not show the city in a good light were queried, though the concerns were quickly dismissed:

> DCC1: So there is no interpretation at the moment? You're displaying data but not interpreting it?
> R1: No, we're just displaying the data.
> DCC1: One of the issues about indicators is you've got to be smart enough about how to do it. You don't want to set yourself up for criticism.
> R1: You can't work that way. If people know you have the data, but you don't show it, it looks like you're trying to dupe them. You might not look good on this indicator right now, but you did seven years ago and you probably will again in a few years. You can't pick and choose indicators as and when they suit. You have to live with the negative trends as well as the positive.

> DCC2: Transparency is a big thing. You can get kudos for doing this. Doing so [making data available] can help drive performance.
> (Meeting at DCC 22 August 2014).

This conversation demonstrates the tensions inherent in making data available and in what way (i.e., with or without context) and how the approach adopted can be positively spun as demonstrating the local authority's commitment to transparency and directing activity to areas which need improvement.

The second meeting was to demonstrate the site to the CEO and to get sign-off for the launch. The CEO claimed he was a healthy skeptic of smart cities and again there was some discussion about the interpretation of the data. In particular, the interpretation of the SCATS data (road traffic data) was questioned, which the CEO did not think was the most reliable way to show what was really happening with city traffic. These comments were likely informed by the CEO's previous role and experience as Director of Traffic in DCC. Despite this the dashboard was enthusiastically endorsed and it was proposed that the site be launched sometime in late September or early October subject to the availability of the CEO to attend and the availability of DCC's Wood Quay venue. Over the next few days the launch date was set for 19th September. In late August the first paper about the dashboard was presented at a conference.

During late August and early September the majority of effort was expended on organizing the launch -- setting the programme, inviting guest speakers, identifying potential attendees and creating a mailing list, drafting an invite and a press release and getting them both approved and signed off by the DCC CEO's office and the university communications office, sending out invites, organizing refreshments and seating arrangements, and getting new Programmable City promotional material produced -- as well as ongoing tinkering with the dashboard website. Having been concerned with whether we would attract many attendees, within a couple of days of sending out the invites we had reached the room quota of 120 and had to retrospectively cap the number of attendees from any one organization to create new spaces, and then start to decline RSVPs. In the second week of September we also produced a short video (1.45m) providing an overview of the dashboard. Three days before the launch we had held a meeting with DCC to run through the site as it would be launched and also the launch programme and practicalities on the day.

The dashboard was formally launched at an event lasting two hours, including an extensive demonstration of the site. It had a full house, with attendees from across the public,

private and civic sectors. The site and launch were covered by RTE radio, television and website, the Irish Times, the Irish Independent, The Sun, and Council Review, and FM104 and KFM radio. There was a steady stream of traffic to the website throughout the launch day. In the wake of the launch the dashboard was presented at a Code for Ireland event at the end of September, with attendees invited to contribute to existing modules or create new ones (which was not taken up), as well at the Web Summit in Dublin and the Smart City Expo in Barcelona in November.

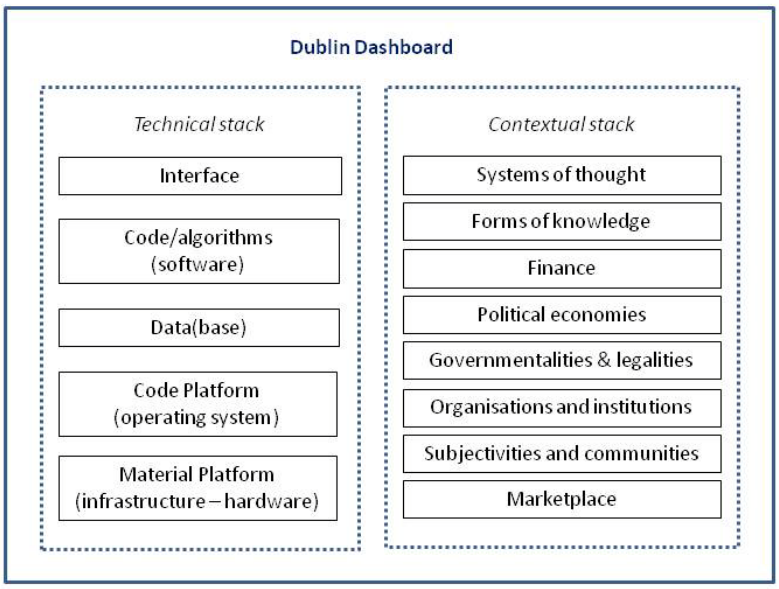
The launch did have the desired effect of leveraging some additional real-time data sets. It also led to a handful of companies approaching us to either seek to commercialise the dashboard for deployment in other cities, or to use the dashboard to drive traffic to their own sites. We were also approached by other Irish cities and local authorities looking for the dashboard to be replicated for their jurisdiction, and by research institutes interested in the project being affiliated to them. Subsequently, we have co-applied for funding to build the equivalent of Dublinked and the Dublin Dashboard for Cork, and have opened a dialogue with a research institute with a view to formal collaboration. We have continued to add additional data into the site, have launched two new modules, and have accommodated new data initiatives within the dashboard, such as the Dublin Economic Monitor produced by DKM (an economic consultancy) for DCC. What also emerged after the launch was feedback that the other three Dublin local authorities felt aggrieved for not being given the opportunity to participate in the original partnership. Although the Dashboard does include data for these authorities, they were not formally consulted and their logos not included on the site. We have subsequently started to build a closer working relationship with Dublinked (which includes the four local authorities as partners) and have started to plan a second phase that includes all four authorities. Most recently we have started to explore with DCC the possibility that Dublin might apply for ISO 37120 certification (smart city indicators) and have started to prepare a second grant application that will convert the dashboard to work more optimally on mobile devices and to develop the social media and modelling modules.

Unpacking the Dublin Dashboard assemblage

Our story of the initiation and building of the Dublin Dashboard makes a number of things clear about the nature of dashboards, their development and operation. First, the dashboard is not simply a technical assemblage of networked infrastructure, hardware, operating systems, assorted software, data and an interface achieved through neutral, objective processes of scientific conception, engineering and coding. Rather, the dashboard is a complex socio-

technical assemblage of actors and actants that work materially and discursively within a set of social and economic constraints, existing technologies and systems, and power geometries to assemble, produce and maintain the website. One way to conceive of such a socio-technical assemblage is illustrated in Figure 2, where the left hand column is the technical stack – the configuration of components, platforms, instructions and data – that enables the dashboard to materially function and operate, and the right hand column is the contextual stack of philosophy, ideology, knowledge, finance, political economies, governmentalities, laws, protocols, standards, institutions, people and markets (as detailed in Table 1) that creates the conditions to enable the dashboard to be built and shapes its form and specification. As such, in building the dashboard we had to be mindful of technical choices and constraints (not least the form or absence of suitable datasets), evaluate different potential technical solutions, and assess the success of solutions implemented, but importantly these did not happen in a technical bubble, but within social, political, legal and financial context. Choices, solutions and assessment were debated, radically altered, and refined, the negotiations refracted through knowledge, experience and desires, and structured by resourcing, laws, standards, protocols, and power dynamics (the team is hierarchical; DCC control access to resources such as data, etc.). These two stacks are mutually constituted creating a thoroughly entwined socio-technical assemblage that binds a multiplicity of elements, apparatus and practices into a set of relations that appear to be singular and coherent.

Figure 2: The Dublin Dashboard as a socio-technical assemblage



Second, the production, maintenance and on-going research and development of dashboards unfold contingently and relationally. Dashboards evolve through a series of individuations and transductions (Mackenzie 2002; Simendon 1992). Transduction is a process of ontogenesis, the making anew of a domain (e.g., a dashboard) through reiterative and transformative actions (Mackenzie 2002). Like a crystal starting as a 'tiny seed which grows and extends itself in all directions in its mother-water' (Simondon 1992: 313), with each layer of molecules serving as the structuring basis for the layer that is being formed next, the Dublin Dashboard accreted from its seed idea within the mother-water of the university and DCC. The process of transduction unfolds as a set of individuations (small incremental steps, or singular radical transformations) that provide partial, always incomplete solutions to relational problems (Mackenzie 2002), where the problems in this case consisted of deciding which indicators and variable to include in the graphs and maps, determining how best to source, manage, process and visualize data, organize, design and implement the interface, implement forms of analysis, purchase the domain name, configure the servers, and so on. Individuations can consist of speech acts, physical movement, mental occurrences, memories, psychological perceptions, physiological sensations, and so on, with the process of individuation resulting in a modulation in conditions (e.g., incremental changes in the design, scope, function, organization of the dashboard). Most individuations are ordinary – routine, habitual, banal (e.g., data is collected, inspected, cleaned, transformed) – others are more exceptional (e.g., deciding to radically extend the scope of the dashboard to include many more modules). Such a process of individuation is illustrated in the following discussion concerning site design that took place when reviewing on-going development:

> R1: We just need to have a little rethink of design. I'm still tempted, on this bit here [points at screen], to do the same as at the top. Get rid of that line either side you know.
> R2: Yeah.
> R1: I might line them up, say with those two. [redirects pointing finger] Or maybe get rid of them.
> R2: Start it here on the black.
> R1: Yeah, tidy it up. But maybe we could do this and then at least there's a logic as to how they're laid out.

R2: mmhmm.

R1: Would you have to keep going up a level though to get back down again? How's it work at the minute if you go into the economy section?

R2: If you went to economy? Yeah, you can just go back to here if you went to, click here, you're back to the main page.

R1: You have to keep going back up?

R2: Yeah.

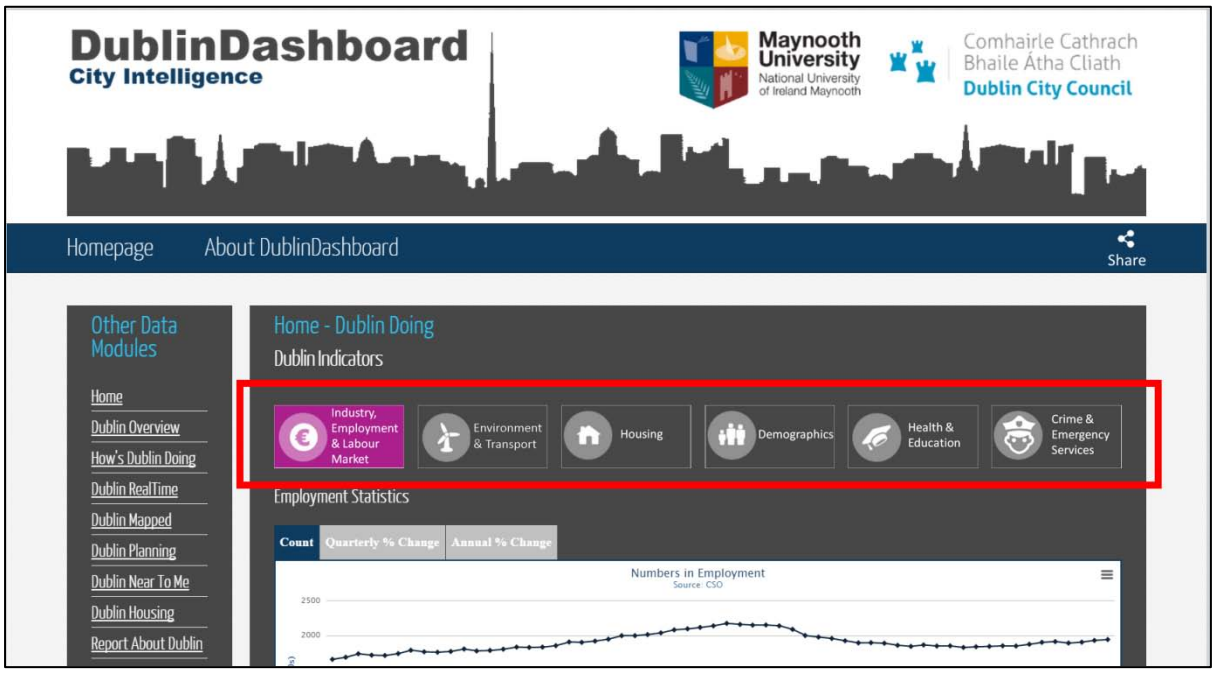
R1: There's no way of navigating on the lower level is there?

R2: I could put it in maybe. I could put them all across the top.

(Internal meeting 12 June 2014)

This process of individuation resulted in a design change in the Dashboard and the inclusion of a new interactive menu for navigating between indicator themes which is highlighted in Figure 3.

Figure 3: Individuations drove the design and functionality of the DublinDashboard; in this case, the addition of an interactive menu (in red box)



Understood in this way, the dashboard is ontogenetic in nature, constantly in a state of becoming; emerging citationally through a series of provisional answers to relational questions. As noted above, these provisional answers are contingent on the wider context in

which the dashboard is emerging, and are negotiated, contested, implemented, rescinded, re-instated, and re-visioned. Moreover solutions are enacted through the performativity of actors whom have varying subjectivities, personalities, knowledges and agendas, and are working together within specific social and institutional relations and settings, and are shaped by the capacities of other actants (e.g., the functionality and malleability of software; the data stock within repositories). And as new ideas and knowledges emerge, technologies are invented, organisations change their personnel, structures and policies, business models are created, political economies alter, regulations and laws introduced and repealed, skillsets develop, the dashboard potentially evolves and mutates accordingly. This continual process of becoming is in itself challenge, as the developer who built the dashboard lamented whilst coding to improve the colour scale gradient on the travel maps, "These little things take so much time and no-one sees it or understands." (11 September 2014). What this contingency and relationality means is that there is no right way to conceive and implement dashboards and no two dashboards will be identical in deployment (even if they are supposedly standardized off-the-shelf products).

Third, the praxis and politics of creating a dashboard has wider recursive effects. Just as building the dashboard was shaped by the wider institutional landscape, producing the system inflected that landscape, sometimes in profound ways. The discussions concerning the dashboard produced reflexivity within DCC about its data production and management and its wider smart cities strategy:

> R1: There are two main issues for the organisation: How do we get the data and get it in the dashboard? How do we get the organisation to format its data into live feeds so we can pull it in directly? ... It's about data but it's also about the way that data is released. If it's in a JSON file it's automatic. If it's in a PDF you have to cut and paste it. We need a live feed to link to.
> DCC1: As an organisation we should set an example to put everything in JSON files which I think Dublinked is doing. But then we need to make sure our other organisations do the same thing.
> DCC2: Putting structure to the data. Not just a dump of data.
> DCC1: We need to make this visible on our own website but also it needs to be visible on key partner websites. (DCC meeting 22 August 2014)

In this sense, the dashboard did not just cast light on how Dublin as a city was constituted and performing, but also cast light on DCC's management structure, the siloing of operations and data production across the organisation, as well as identifying shortcomings and gaps, and the fragmented and somewhat ad hoc approach to smart city development. This was already apparent to the organisation, hence the appointment of a smart city coordinator and the Dublinked manager prior to the project commencing, but the dashboard discussions provided critical dialogue and inflected reflection and change management. Moreover, the dashboard did lead to new data being opened and made available for use.

At the same time, our engagement with DCC and other state agencies altered our thinking with respect to the parameters, design and approach being taken and our perception of the issues and tasks at hand. It also inflected our wider thinking on smart city technologies and most specifically their messy and contested visioning and deployment by and within local authorities. Whilst the narrative spun by companies, and often also city management, suggests that the transition to a smart city is a smooth path of rollout and integration the reality is a set of iterative processes of debate concerning needs, desires, specifications, technologies and costs framed by laws, governmentalities, budget, political ideologies and so on, and messy processes of implementation that are often resisted by units and staff who are used to existing systems and procedures and have limited resources to help effect change management. In entities as large and diverse as a city authority there are multiple overlapping visions and forces that continually jostle with one another, sometimes aligning, other times competing, whilst the institution as a whole tries to present a coherent set of policies and strategies for delivery. The localised production of a smart city then unfolds within this emergent context, its path dependency never assured, as our experience of building the dashboard attests.

Fourth, the data, configuration, tools, and modes of presentation of a dashboard produce a particularised set of spatial knowledges about the city. Whilst the dashboard might seek to show the city as it actually is, it is inevitably partial and limited. Dashboards only visualize a sample of the data that exists with respect to the city (even if it included all the data held by public agencies it would still exclude that held by private institutions and companies and citizens). The data included is generated in particular ways, with a selected field of view, a certain sampling frame, and biases and errors, shaped by the methods, technologies, calibration and data ontologies employed in producing and processing them (Kitchin 2014b). Moreover, there are lots of data that do not exist, or exist with unsuitable spatial and temporal resolutions, as we discovered when conducting our data audit. Further,

how the data can be presented is mutable, with dozens of potential modes of display that can be coloured and scaled in varying ways, each of which reveals and conceals different trends and patterns within the data. As Openshaw (1984) reveals, this can lead to all kinds of ecological fallacies, for example the modifiable areal unit problem wherein data displayed at different territorial scales reveal markedly different patterns and thus lead to varying conclusions. In other cases, data might have to be aggregated or transformed to comply with data protection laws. As such, dashboards provide oligoptic views of the world: views from certain vantage points, using particular tools, rather than an all-seeing view (Haraway 1991; Amin and Thrift 2002). Dashboards undoubtedly strive to be more exhaustive and provide dynamic, fine-grained insight but, nonetheless, their promise can never be fully fulfilled.

Moreover, even when seemingly fixed and static as a published website, the dashboard continues to be ontogenetic in nature. As Kitchin and Dodge (2007: 331) argue in relation to maps (of which there are hundreds in the Dublin dashboard), the data and visualisations within the dashboard are never static but are 'always in the process of being (re)made, brought into being through practices (embodied, social, technical).' As such, when one interacts with a dashboard its technicity (power to make things happen; Mackenzie 2002) is evoked in context and in conjunction with the user to generate a particular spatiality, an instance of code/space (Dodge and Kitchin 2005). The spatiality and spatial knowledge presented enables the user to seek and deploy an incomplete answer to relational question (e.g., how is the city performing? what is happening in the city right now? what is the nearest facility to me and when is it open? what is the pattern of social inequality across the city? how can I report an issue to the city authorities? etc.)

Conclusion

Urban data are presently proliferating, as are ways to make sense and act on those data. Urban dashboards are one way to collate, process, visualize, analyze and share urban data, and are becoming more common as various cities invest in their development. The power of these dashboards is their assumed realist epistemology and instrumental rationality, and their supposed ability to translate the messiness and complexities of cities into rational, detailed, systematic, ordered forms of knowledge; to enable us to know the city as it actually is. In this paper, we have provided a critique of such a view by critically unpacking the building of the Dublin Dashboard drawing on an extensive set of empirical observations generated via participant observation, ethnography, and an archive of correspondence. Our analysis has challenged traditional scientific approaches to developing dashboards (and other smart city

technologies) that treat them as neutral, commonsensical technical exercises and their underlying data as objective and value-free. Instead, we have highlighted the emergent politics and praxes of urban data and dashboard design; how the dashboard is a complex socio-technical assemblage that unfolds contextually, contingently and relationally, and produces diverse spatial knowledges about the city.

We have been careful, however, to avoid suggesting that because of the politics and praxes we have identified that dashboards have little utility. Rather, we believe, urban dashboards have much to offer city managers who need detailed information about the city to aid service delivery in a time of reduced budgets, companies who want to understand local markets and develop products based on open data, and citizens interested in finding out what is happening in a city. At the same time, it has to be recognized that dashboards provide partial views of a city that are inflected with the design choices and actions of their designers and commissioners, which emerge within contexts and structures. Following Kitchin *et al*. (2015), we thus contend that the creators and owners of dashboards need to explicitly recognize in their accounts of dashboard development that they constitute socio-technical assemblages and that their underlying data and visualizations produce a particular understanding of the city, and likewise policy produced and governance enacted on the basis of insights gained from the dashboard are the outcome of a specific empiricist epistemology.

As far as we are aware, this is the first in-depth empirical study of the development of an urban dashboard that treats them as socio-technical assemblages and adopts the perspective of critical data studies. It is our view that there is a pressing need for further such studies to widen the empirical base and enable comparison between dashboard initiatives and provide more evidence from which to conceptually unpack their creation. This future research would no doubt benefit from the use of other methodologies, such as in-depth interviews with all actors, tracing the interconnections and interdependencies of the various actants, and deconstructing the attendant code that determines how the dashboard looks and functions. Further, there is a need for research on the everyday uses of dashboards and how they are used by different constituencies (e.g., city managers, policy makers, citizens) for different purposes and within different spaces (e.g., within control rooms, within public spaces using displays, whilst travelling across a city), using different platforms (e.g., websites and mobile devices). And finally, there is a need to further develop our conceptual understanding of urban data and dashboards. We have provided one critical lens through which to make sense of urban dashboards, but we are aware that other approaches might provide additional useful insights.

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