The timescape of smart cities

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Abstract

To date, critical examinations of smart cities have largely ignored their temporality. In this paper I consider smart cities from a temporal perspective arguing that they produce a new timescape and constitute space-time machines. The first half of the paper examines temporal relations and rhythms, exploring how smart cities are the products of and contribute to space-time compression, create new urban polyrhythms, alter the practices of scheduling, and change the pace and tempos of everyday activities. The second half of the paper details how smart cities shape the nature of temporal modalities, considering how they reframe and utilise the relationship between the past, present and future. The analysis draws from a set of 43 interviews conducted in Dublin, Ireland, and highlights that much of the power of smart urbanism is derived from how it produces a new timescape, rather than simply reconfiguring spatial relations.

Key words: time, timescape, temporality, space-time, smart cities, rhythm, pace, tempo, scheduling, real-time, past, present, future

Introduction

Over the past decade many cities around the world have declared the intention to become a 'smart city'. A somewhat nebulous term, in general there are three broad understandings of what constitutes a smart city (Kitchin 2014). For some, a smart city is one in which urban infrastructure and services are managed computationally, with networked digital instrumentation embedded into the urban fabric producing continuous streams of data that dynamically feed into management systems and control rooms, creating new forms of governmentality (Vanolo, 2014; Sadowski and Pasquale, 2015; Luque-Ayala and Marvin 2016). For others, a smart city is one in which the strategic use of ICT produces smarter citizens, workers, policy and programmes; fosters innovation, economic development and entrepreneurship; and produces urban resilience and sustainability (Giffinger and Pichler-Milanović 2007; Caragliu *et al*., 2009). These two visions are largely underpinned by a neoliberal ethos of market-led and technocratic solutions to city governance and development whereas, in contrast, a third position casts a smart city as one adopting an ICT-led, citizen-centric model of development that fosters social innovation and social justice, civic engagement and hactivism, and transparent and accountable governance (de Lange and de Waal 2013; Townsend 2013). These three understandings are not mutually exclusive and the smart city strategies adopted by cities seek to blend elements of them in varying proportions and emphases.

Accompanying the development of a global smart cities movement has been critical analysis that examines the nature and consequences of smart urbanism. To date, such analysis has focused primarily on how the technologies and processes of smart urbanism reconfigure modes of governance and urban development and reshape the production of space and spatiality. For example, Thrift and French (2002) outlined the automatic production of space by software-enabled technologies, and Dodge and Kitchin (2005) detailed the transduction of space by code and the creation of new spatial formations such as code/space. Graham and Marvin (2001) set out how networked infrastructures produced forms of splintering urbanism (a fractured and uneven set of urban services and city landscapes), and Graham (2005) documented the creation of software-sorted geographies. Foth (2009), Verhoeff (2012) and Elwood and Leszczynski (2013) detailed how urban informatics and spatial/locative media are producing new spatial imaginaries and knowledge politics. Shelton et al. (2015) examined the 'actually existing smart city' and how networked technologies are enrolled in the neoliberal production of urban space, and Datta (2015) detailed how the smart urbanism agenda is creating a set of contested spaces in India as land is reallocated for the development of 100 new master-planned cities. Townsend (2013) and Kitchin (2014) charted how the internet of things (e.g., networked cameras, sensors, and meters) produce new layers of surveillance and enable new forms of technocratic and corporatized control of urban space.

In contrast to the focus on space and spatiality, there has been comparatively little consideration of the relationship between the development of smart cities and time (though there is a well-established literature exploring the temporality of cities more broadly and the relationship between space, time and technology; see Parkes and Thrift 1980; Massey 1992; Castells 1996; May and Thrift 2001; Hassan and Purser 2007; Schwanen 2007; Dodgshon 2008; Edensor 2010). Where time and the temporality of smart cities has been examined it is usually with respect to the increasingly real-time nature of urban management and governance, in which streams of big data flow into urban control centres and are used to manage urban systems based on present conditions, and how such data are parsed to citizens through spatial and locative media accessible via smartphones (e.g., de Waal 2013; Kitchin 2014; de Lange in press; Leszczynski 2015a; Coletta and Kitchin 2017); though Datta (2017) details how speed and the temporal changes wrought by smart city initiatives are a critical element in enacting 'fast urbanism' in the Global South – a means to manage rapid urbanization.

In this paper, I examine more thoroughly the temporality of smart cities and how smart city technologies are reconfiguring the space-times and temporal relations of cities to produce a new timescape, and how temporality is deployed to imagine and drive smart city initiatives. Adam (2004) describes a timescape as a cluster of associated temporal relations (time frames, temporality, tempo, timing, time point, time patterns, time sequencing, time extensions, time past, present and future) that are implicated with each other (though not necessarily of equal importance) and work to produce a particularized temporal landscape. She contends that the notion of 'scape' is important because it 'indicates, first, that time is inseparable from space and matter, and second, that context matters' (p. 143). I contend that smart cities are space-time machines, with networked infrastructure and smart city technologies significantly disrupting temporality as well as spatiality to produce a new set of space-time relations.

This disruption is somewhat paradoxical. On the one hand, some smart city technologies are designed to more effectively measure, order, manage and predict temporalities – to create efficiencies in the timeliness of work practices and service delivery and to produce more regular and consistent temporal rhythms. For example, a predictive policing system seeks to direct police activity by drawing on past patterns of crime and present conditions to predict the future locations of likely criminal activity and the optimal patrol routes to minimize and tackle crime. On the other, some technologies are designed to provide greater temporal flexibility and freedom by enabling on-the-fly planning and action and serendipitous meetings, such as location-based social networking. In both cases, time is revealed as contingent, relational, performative, multiple, and intimately bound to space in shifting and contextual ways, being produced and experienced differently across people and places. Moreover, the effects of digital, coded devices and infrastructures are critical to its production. In this sense, Dodge and Kitchin's (2005) notion of code/space, in which the transduction of space – how space is continuously bought into being – is dependent on code, is perhaps better reframed as code/spacetime.

The analysis draws on a set of 43 interviews conducted with smart city stakeholders (7 from local authorities, 9 from state agency, 6 from large companies, 3 from SMEs, 7 university researchers, 5 from civic groups, 3 from lobby groups, and one politician) in Dublin undertaken between February and December 2015 as part of a large EU-funded project. The interviews sought to understand the extent to which Dublin was becoming a smart city and was not specifically designed to examine notions of time and temporality. The interest in time was sparked by the first interview coded in which several registers of time – peak times, evolutionary times, cyclic times, real-time, Christmas time – were mentioned.

> Well, I suppose in common with most large cities we have had a traffic control centre for a *number of years*. So our first traffic control centre was built around 1987 or even 1986 and it has gone through several different *iterations* and expansions and so on. The *latest version* of it was considerably changed in 2013. The traffic management centre itself is a *24 hour, 7 day a week* operation, it is staffed by our own control room operators. At *peak times* it has people from AA Roadwatch, which is the motoring organisation here. We have facilities for the police and the public transport service to be here as well, so *at the moment* during the run up to the *Christmas busy time* they are in there *every day*. So we have somebody from the police and somebody from the public transport operators. We also have our own dedicated radio station which broadcasts *six hours a day, 7:00 to 10:00 and 4:00 to 7:00*. And the idea of that is it provides very detailed traffic information to people in very much a *real-time* fashion using all the cameras and the technology that we have in the traffic control centre. (SDP43: Senior executive manager, Local Authority, my emphasis)

Examining the other interviews it was apparent that time was a common refrain. The interviews were thus coded with respect to temporal concerns, focusing on the configuration of temporal relations, and relationship between past, present and future in the production of smart cities. Elsewhere, drawing on the same and a related dataset, myself and Claudio Coletta provide a rhythmanalysis of a how traffic control room, and its distributed network of inductive loops, cameras and citizen-reporting, is used to manage the concatenated rhythms of mobility in the city (Coletta and Kitchin 2017); an exploration of the 'realtimeness' of urban internet of things (Kitchin 2017); and an analysis of the intersection of temporalities in conducting an ethnography within a control room with the practices of space-time management of traffic across a city (Coletta 2017).

Temporal relations and rhythms

It has long been argued that networked ICTs radically reconfigure space-time relations, leading to significant time-space compression, a transformation in the concatenated temporal rhythms of cities, and a change in the pace and scheduling of everyday life (Castells 1988; Gillespie and Williams 1988; Graham and Marvin 2001). Such temporal-spatial shifts are a key aspect driving: the creation of smart cities (to overcome space with time to produce economic development, accumulate capital, and create efficiencies in the delivery of public services); the form, functioning and governance of urban and regional systems (as densely interconnected, interoperable, resilient, sustainable systems); and in the experience of living and working in smart cities (as always-on, hyper-mobile, performative places).

Time-space compression: convergence and distanciation

Time-space compression consists of two related process. Time-space convergence is the shrinkage in time taken to communicate or travel between locations (Janelle 1968). New communication and transport technologies and infrastructures have eroded successively the friction of distance by fulfilling Marx's (1857) maxim that capital creates new markets and accumulates by 'annihilating space by time'. Since the invention of the telegraph, communication between distant places has increasingly become real-time in nature. With the internet, satellite and mobile technologies, it is now possible to access vast quantities of diverse information anywhere on the planet and while on the move. In turn, this has enabled significant time-space distanciation; that is, the interpenetration and integration of places over long distances (Giddens 1984). For example, companies can organize their operations across the globe, with workers in one location being overseen from another, and vast, complex logistics networks being managed centrally. People, goods, services, information, and capital flow between locations creating independencies, so that what happens in different places affects what is happening elsewhere, milieus becoming simultaneously local and global (Massey 1991). Castells (1996) terms this hyper-connected spatial-temporal logic the ‘space of flows’ in which instant communication and swift long distance transport enables rapid, fluid mobilities, interactions and transactions, supersede the more rooted and less static nature of the ‘space of places’. This has led some to declare the ‘death of distance’ (e.g., Cairncross 1997) in which social and capital relations are freed from modernist spatial logic. And others to contend that time becomes *the* crucial dimension and resource of social and economic life rather than space (Mitchell 1998).

For Giddens (1990: 29), space-time distanciation creates a synchronicity between places, wherein activities are disembedded from local contexts and re-organized across large time-space distances and places across the globe can experience shared moments within a ‘global present’ (e.g., simultaneously watching a global sporting event or media story, or interacting via social media). For Urry (2000: 129) this produces what he calls ‘instantaneous time’; which holds different qualities to routinized, national clock-time, for example: synchronicity across time zones; a breakdown of distinctions between day and night, weekdays and weekends, and flexibility in working hours as employment and social practices change; volatility, disposability and mobility of fashions, products and ideas; an erosion of established temporal norms such as family meal times; just-in-time logistics; and either instantaneous delivery of goods and services (via ICT, such as digital music, books, tv/movies) or speedy delivery (within hours or next day). Similarly, Castells (1996) argues that the space of flows is characterised by what he terms ‘timeless time’, wherein temporality 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. Moreover, the temporal codes within systems can be split and spliced, so data generated at, or referring to, different times can be recombined in non-sequential forms, inducing a condition of ‘timelessness’. Every time an ICT network is accessed and used, he argues, timeless time – timelessness and simultaneous presence - is invoked. Such timeless time contrasts strongly with ‘natural’ time (e.g. Earth seasons, diurnal cycles, body clocks), ‘social’ time (e.g. national holidays, celebrations, festivals, holy days) and the predictable ‘clock’ time of the industrial age.

Time-space convergence and distanciation are having profound effects on urban economic development, with the drive to create smart cities in part a strategy for capturing inward investment and creating startups and growing indigenous industry by providing a sufficient agglomeration of ICT infrastructure and attracting sufficient talented labour, as well as creating new markets of urban ICT infrastructure and management (e.g., new internet of things platforms), real-estate investment, and urban knowledge (e.g., consultancy and apps). In turn, this is having an effect on the global urban system and on the form and functioning of urban locales and regional development. In contrast to the death of distance thesis, the space of flows is still highly uneven, since space-time compression is uneven and there are other factors that affect the location of industry, such as property and labour costs, business regulations, and quality of life (cost of living, congestion, etc) (Dodge and Kitchin 2000).

On the one hand, there are centralising forces, with companies receiving significant spillover effects from the urban agglomeration of ICT networks, talented labour, and density and range of complementary businesses, leading to a consolidation of economic power and investment into major world cities, and to particular districts within them (Castells 1996). For example, Singapore is a city that has formulated and undertaken successive strategic policies and investments in networked infrastructure over four decades (the latest incarnation being Smart Nation[1]) to leverage space-time compression to create a smart city that has become a regional economic powerhouse and global business hub, attracting inward investment, increasing competitiveness, creating a well-educated workforce, and improving quality of life (Mahizhnan 1999; Calder 2016). On the other hand, there are decentralising forces, with many office activities, business services and production centres shifting either to lower-order cities or to the edges of metropolitan areas to take advantage of no loss of time in delivery, but lower rent and labour costs, lower worker turnover, better worker accessibility, and a skilled, suburban labour pool (Castells 1996). This decentring requires centralised command-and-control and deepens time-space distanciation and the interdependencies between locations. Geography is still of importance, with patterns and processes of urban development and a city's relationship with its surrounding region and other cities being transformed rather than erased. As a consequence, there are uneven geographies of time-space compression, with some cities utilising smart city technologies to consolidate their advantage or to reposition themselves in the global urban order.

[1] https://www.smartnation.sg/

With respect to Dublin, since the late 1980s the city has benefitted from the processes of centralisation and decentralisation produced by space-time compression, using networked services industries to drive rapid economic growth. Breathnach (2000) details that initially the Irish state pursued a strategy of entrepreneurial urbanism, using planning and tax conditions alongside significantly improved ICT infrastructure, to attract low-skill services and high-skill manufacturing to replace an ailing branch-plant economy (with functions decentred predominately from the USA to Dublin). In the 2000s, the state sought to attract higher-skill service jobs and the European headquarters of global tech companies, creating centralised hubs of ICT-led economic activity, with Dublin seeking to implement a creative cities strategy and to leverage the time-space distanciation of being plugged into the global informational economy (Kitchin and Bartley 2007; Lawton et al., 2014). In the 2010s, the focus has shifted to Dublin becoming a smart city in large part to drive economic recovery after the financial crisis, with the city creating an open data portal, a new unit – Smart Dublin – to coordinate smart city initiatives across four local authorities, and sponsoring hackathons and procurement-by-challenge initiatives designed to create new startups, as well as enabling testbed urbanism that makes city spaces available to companies to trial and test new products as a way of attracting new FDI (Coletta et al., 2017). This urban entrepreneurial strategy of pursuing a networked economy has been highly successful, moving Dublin and Ireland from the European periphery, with the second lowest GDP in the European Union in 1987, towards the centre, with the second highest GDP by the early 2000s (Breathnach 1998; Kitchin and Bartley 2007). Moreover, it has led to dramatic urban-regional restructuring, with a large growth in population, extensive suburbanisation of housing and office/industrial premises, and poly-centric development. Overcoming peripherality with time has thus had a profound effect on the city (though the friction of distance at the local scale remains a significant issue due to uneven resources and congestion).

Temporal rhythms

While time-space compression disrupts 'natural', 'social' and 'clock' time by producing 'instantaneous' or 'timeless' time, it does not erase them or local instantiations of time (Crang 2007). As Lefebvre (1992[2004]) and others (see Edensor 2010) have argued cities and everyday life unfold through cycles of polymorphic and concatenated temporal rhythms which produce a sense of continuity, stability or disjuncture. Peoples' lives take place within a set of oscillating space-times, some of which are encountered regularly, some more periodically. Lefebvre identifies two main types of rhythms, linear and cyclical repetition. Linear repetitions are 'imposed structures' through social practices such as clock time and timetables, whereas cyclical repetitions are 'lived time' originating in the 'cosmic, in nature: days, nights, seasons' (Lefebvre 2004: 8). May and Thrift (2001) thus note that people's socio-spatial practices are rhythmically conditioned in at least four ways: (1) natural cycles, such as the diurnal cycle, seasonal change, turning of tides, bodily rhythms; (2) social discipline, such as religious or work or official timetables, or meal-times at home; (3) instruments and devices, such as sun dials, clocks, video recorders, transportation, smartphones; and (4) texts that codify and shape one's understanding of time, such as timetables. As Lefebvre (2004) notes, people are often encountering and co-producing several rhythms simultaneously such that cities host a series of 'intersecting rhythms, including the polyrhythmic [multiple], eurhythmic [harmonious and stable], isorhythmic [equal and in sync] and even arrhythmic [out of sync and disruptive] measures as well as secret, public, internal and external beats that comprise the symphonic everyday' (Conlon 2010: 72-3). In other words, cities consist of a 'multiplicity of temporalities, some long run, some short term, some frequent, some rare, some collective, some personal, some large-scale, some hardly noticed' (Crang 2001: 190). These rhythms 'may clash or harmonize, producing reliable moments of regularity or less consistent variance' (Edensor and Holloway 2008: 484). The urban fabric thus pulsates rhythmically, producing a 'topology and texture of temporality' that frames and mediates urban life (Crang 2001).

Many smart city technologies, such as urban infrastructures mediated by software and the internet of things, and control rooms, are designed to augment and regulate the multiple rhythms of cities; to limit arrhythmia and produce eurhythmic systems that maintain a refrain. Such technologies are 'algorithm machines' (Gillespie 2014) that perform new forms of algorithmic governance, working to monitor and manage automatically, quickly, efficiently, effectively and inscrutably how systems are performing and the space-times of cities in order to produce consistent patterns of rhythms. In effect algorithms act as 'algorhythms'. Miyazaki's (2012) notion of 'algorhythm' blends together the step-by-step instructions of an algorithm with the time-based order of rhythms' movement to capture how computation 'manifests itself as an epistemic model of a machine that makes time itself logically controllable and, while operating, produces measurable time effects and rhythms' (2012: 5). Miyazaki (2012) shows how the micro-temporal 'agencement' of such algorhythms produce and mediate everyday life, but can also generate major failures in networks and services and severe temporal dissonance, such as in the cases of the AT&T telephone network crash in 1990 or the Flash Crash of the New York Stock Exchange in 2010.

Coletta and Kitchin (2017) demonstrate how the rhythms of urban systems and the space-time unfolding of place are algorhythmically mediated through a case study of a traffic control room that processes real-time data generated by a dense network of sensors and cameras to automatically sequence traffic lights and synchronize the flow of traffic, and of a sound network used to monitor and model noise pollution. For one respondent, such algorhythmic systems are useful because they seek to capture and regulate the 'heartbeat of the city' (SDP42); to know and manage the flow of people, goods and services around the 'body' of the city (see also our quote in the opening section). And this information can be used to predict and calibrate future flow and to inform citizens in real-time about how to synchronize their own actions with the temporal rhythms of urban services. The utility of a city dashboard or control room is to disentangle the 'assemblage of different beats' (Crang 2001: 189); to separate out the pluralistic, concatenation of beats so as to help make sense of particular rhythms.

The temporal rhythms of cities can also work over longer timeframes and some of the respondents contended that Dublin's desire to become a smart city is tempered by mis-synchronization between rhythms with different refrains and durations. For example, a manager with a large multinational company noted:

> "[I]f you think about a city, let's take Dublin as a specific example, they have already celebrated their 1000th year anniversary, so when you think about the physical city you have to think in terms of the pulse rate being 30 years; a heartbeat in Dublin terms is 30 years because that is how long it takes to conceive of and build a bridge. You are looking at timelines that are not driven by electronic internet time clocks. … [D]ecision making needs to be made in the sense of I am investing in a piece of infrastructure that must last for 100 years. [In contrast], homelessness … is a very immediate sharp focus problem, depending on government policy it may be more or less of a problem in a particular month, year and so on. *So there are many different timelines and tracks within a city.* … So you can't simply come in and say, we are going to make a super highway to the docks. That doesn't happen. And it doesn't happen in anything less than 20 years anyway.' (SDP29, my emphasis).

Similarly, a state agency official stated that their organization often talked:

> ‘about the clock speed of tech and the clock speed of cities … [I]f a new technology emerges every two years but a city council takes a five years to build a case flow starting a new department there is going to be a real problem … I have great respect for all those forward thinkers in [a local authority] but stick them in a room full of Google people and they are just on a different clock speed, the culture is completely different. … [I]f you walk into any room in the tech industry most of the people in the room, if you ask them “will you still be here in five years’ time?” the answer is no … So they need to complete their projects on six month timelines. … [I]t is a huge amount to ask the city to act in the same clock speed.” (SDP37)

Becoming a smart city then necessitates seeking to harmonize and synchronize the temporal rhythms of a diverse set of practices and processes, something that can be difficult to do because of established routines and institutional cultures. And this can bring the city out-of-line with what other innovative cities might be doing. For example, some of the respondents discussed the notion as to whether Dublin was ‘out-of-sync’ or ‘ahead or behind the curve’ with respect to becoming a smart city, with the owner of a startup company concluding that ‘Ireland was about two years behind where US cities were’ concerning utilising open planning data (SDP42), though Dublin was considered by another entrepreneur as being ahead of the curve with respect to sound monitoring (SDP40). In general, the consensus was that Dublin was behind the curve, needing to catch-up with new technical innovations, policy, and practices if it wanted to be a leading smart city and to gain the benefits of being an early adopter. In other words, it needed to shift from being a second-mover adopter, in which the risks of investment are lower because a technology is established, to a first-mover innovator where technology is immature but the city gains from enhanced space-time relations, economic spillovers (such as new supporting industries), and innovations that can be exported. Smart Dublin seeks such first-mover advantage through running procurement-by-challenge schemes aimed at encouraging start-ups and SMEs to tackle city problems and by facilitating urban experimentation though testbedding (e.g., enabling the trialling of prototypes in the newly designated smart district) (Coletta et al., 2017).

Scheduling, pace and tempo

In his seminal work on time-geography, Torsten Hägerstrand (1970) argued that people moved and planned their lives along space-time trajectories. These trajectories could be plotted within a space-time cube, with the x and y axes representing space and the z axis time. By plotting the circulation of people or goods, service delivery, etc. it is possible to compare and contrast their spatio-temporal movements. Space-time trajectories are performed within the context of what Hägerstrand termed 'projects' (clusters of acts, materials, tools and people required for completing goal-oriented behaviour) and a triplet of constraints (capability, related to personal ability and access to tools; coupling, related to the alignment and duration of necessary conditions; and authority, related to control and autonomy to act (Hägerstrand 1970; Schwanen 2007). Networked and mobile technologies provide a new set of tools to mediate space-time trajectories, and alter the nature of constraints that delimit everyday movements. With respect to the latter, GPS and locative and spatial media are starting to become ubiquitous and they create new modes of coupling; at the same time, movement and location are increasingly open to real-time nudging, surveillance, and forms of discipline and control. As Crang (2007) notes, such technologies are having pronounced effects with respect to the constitution of individual time-geographies in the smart city, including:

- speeding up the delivery of services 'offering quicker access and obviating the travel time, bypassing physical queues, or offering preferential access, by enabling the swift provision of information' (p. 70).
- the 'time shifting of activities to formerly unavailable time slots' (p. 71) and more flexible temporal organization of activities; enabling 'dead time' to be colonized with other activities;
- shortening the time lag between action and event to enable real-time management of systems and regulation of movement;
- changing the tempo and scheduling of events, with the enabling of immediate response, simultaneous occurrences, multitasking and the interleaving of activities (performing several tasks simultaneously rather than sequentially).
- fragmenting events into a kaleidoscope of denser, smaller units of time of diverse activities (that can become a challenge to coordinate and synchronize meaning that people can become more time-stressed).

Collectively, these processes are producing 'faster' and more temporally flexible subjects (Adam 2004; Crang 2007; Hassan and Purser 2007).

Time-shifting, scheduling and planning

For Hassan (2003) and others (see Hassan and Purser 2007) the creation of network time – time fragmented and made simultaneous across globally connected digital networks – is fundamentally changing the meaning and experience of time. Just as the clock shifted our relationship with time from social and natural registers to an abstract mechanical register, networked time undermines, replaces, and co-exists with clock time. Set meal times, clocking-in/out, timetables, pre-arranged meetings and so on, built around the measure of a clock, are traded for greater temporal flexibility and time shifting (events being organized and coordinated on-the-fly across space and scales). Adam (2007: 1) thus contends, networked time is 'globally networked rather than globally zoned. It is instantaneous rather than durational or causal. It is simultaneous rather than sequential.' It shifts the scheduling and planning of activities and events from 'specific times and places' to 'any time, any place'.

For example, in recent years, mobile phones and social and spatial media have altered the practices of coordination,communication and social gathering in space enabling on-the-fly scheduling of meetings and serendipitous encounters by revealing the location of nearby friends, as well as new forms of activism such as swarming and flash mobs (see Willis 2016). They have also enabled access to information about the real-time conditions of transportation networks, such as delays and congestion, enabling route planning to be taken in context and re-routing to optimize travel time. Spatial search and LBSs provide information on and recommendations concerning local businesses, enabling dynamic and contextual spatial choice- and decision-making rather than advanced search and planning. Moreover, they enable on-the-fly time shifting to occur, with diaries becoming flexibly organized around unfolding events, such as people being delayed or unexpected meetings. Importantly, all these tasks can be undertaken in situ, on-the-move and in real-time, augmenting a whole series of activities such as socialising, shopping, wayfinding, sightseeing, protesting, etc. (Kitchin et al., 2017b). Indeed, beyond mobile communication via phone or social media, there are now a plethora of urban apps that are designed to help mediate the experience of living in and moving about cities.

Sutko and de Souza e Silva (2010: 811) thus suggest that location-aware technologies are replacing the proactive management of time and 'the clock as a medium for coordinating meetings in space'. As such, Wilson (2012: 1270) contends that mobile, spatial and locative media produce conspicuous mobility serving to restructure urban experiences as transactions by figuring people's mobilities. For Leszczynski (2015b: 746) this occurs because spatial media enables the momentary comings-together of people and places, with this experience 'intensified by the proximate and synchronous nature of location-aware mobile devices' through which information is 'both generated and called into being both in situ and in real time'. Space-time interactions become more flexible and fluid, with constant connection and access to information enabling new mobilities and spatial practices and reshaping how places are experienced. Indeed, how we understand, relate to, move through, coordinate and communicate in, interact with, and build attachments to space/place is altered (Kitchin et al., 2017). For example, a number of the interviewees discussed how RPTI (real-time passenger information) for public transport was reshaping their travel.

> '[T]he live updating of bus locations and linking that to a mobile app, I think, is a quiet revolution ... If you talked to anyone in Dublin a few years ago about the public transport … they will tell you jokes and stories about the timetables, you might as well be reading fairy tales and all this kind of stuff. That has now changed because I could sit at home, I could look at the bus app and I can see at my stop around the corner from my house there is a bus going to be there in 5 minutes or 20 minutes or whatever. … [T]he lack of predictability has been ... a big chunk of that problem has been taken away.' (SDP39, university researcher)

> '[B]us data has revolutionised my life in a way because it has just made it so much easier to use the system. It's such a trivial thing but actually I think it makes a huge difference. And that has enabled me and a lot more people just to have a bit more agency about you are not just standing at the bus stop feeling like an idiot while the cars zoom by in the rain, you know the bus isn't coming so you go and do something else. So that is surprisingly powerful in a way.' (SDP23, local authority worker)

Further, beyond individual use, smart city technologies, such as a traffic control room, can alter the scheduling of traffic lights on-the-fly to coordinate and prioritize the movements of certain groups of people or modes of transport. For example, the supervisor of the Dublin traffic control room (SDP43) remarked:

> 'As you start to move nearer and nearer to the city you are starting to have competing demands so you want to make sure that pedestrians get a good share of the green time. You want to make sure cyclists can be catered for. And then as you come right into the heart of the city you are trying to more and more prioritise walking, cycling, public transport rather than just simply car use.'

Likewise, city managers can dynamically schedule workflows around the sites of events, as detailed by one local authority administrator (SDP20):

> '... we have internal apps which our staff would use out in the public realm so after the bonfires of Halloween the guys go around with their mobile devices, point them at the site of where the bonfire was, take the photo of it, it picks up the GPS, takes the predefine check boxes and fields and whatever else, bang, it goes back into the corporate system. We can see an example of it actually, where it goes into the public realm system at that stage in a work schedule, and that kind of interaction, that is happening.'

The smart city then is enabling a breaking free from, or the active management of, clock-time by facilitating real-time decision-making, and to be cognizant and flexible with respect to timetabled time, such as bus and train schedules or work schedules.

Pace and tempo

In addition to peoples' time-geographies becoming more flexible and fluid, it is argued that they are being speeded up and gaining tempo. The use of networked technologies are creating a faster and busier world by enabling tasks to be undertaken more efficiently and a state of hyper-connectivity to exist (Virilio 1997). Spatial and locative media, smart routing, control rooms, city dashboards, and coordinated emergency management seek to provide real-time control and synchronicity within and across urban infrastructures and systems and to actively manage what Southerton and Tomlinson (2006) term 'temporal density' (that is, intense, overlapping temporal rhythms caused by multitasking or, in the case of smart city systems the overlapping dense workings of a complex system managing many tasks simultaneously) and 'time scarcity' (the experience of being rushed or harried) (Wacjman 2008). Moreover, they not only to work in real-time but also to seek to anticipate future outcomes and pre-empt density and scarcity issues. Further, not only are temporal rhythms and relations faster, but the rate of technical and social change seems to have accelerated with a succession of new innovations. Rosa (2003) describes three forms of acceleration.

First, the *acceleration of the pace of life*, in which there is a decrease in the time needed to undertake everyday processes and actions of production, reproduction, communication and transportation. Somewhat paradoxically, such a speeding up does not lead to an increase in free time or slow down the pace of life, with the additional time colonized by other activities. Wacjman (2008) contends that is because the 'always-on' nature of networked technologies, particularly mobile media and the internet, enables 'dead time' to be made 'productive time' through phoning, texting, emailing, searching information, sending files, and so on. People thus become 'always-everywhere available' (Green 2002). Moreover, Wacjman (2008) notes that the time-shifting property of networked technologies expands the possibilities for time-deepening activities, such as multi-tasking (completing a task, while undertaking another). As Crang (2007) details, while ICTs hold the promise of helping people cope with the compression, densification and fragmentation of time, 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 all the things needed (Hassan 2007).

Second, *technological acceleration*, the speeding up of technical processes such as the rate of data processing, the speed of transport, the rapidity of communication, and the work pace of manufacturing machines. For example, the head of a state agency stated:

> 'Just speaking purely as a private citizen, when I think about what I can do on my phone now compared to five years' ago, be it Hailo or the buses or looking at the localised weather hour by hour and all that stuff, the pace of change is so massive.' (SDP24)

It is this acceleration that is driving the processes of time-space compression, though it is tempered by frictions such as congestion and bandwidth. It also create efficiencies in the delivery of services by saving time. For example, one of the respondents (SDP38, manager, multinational company) discussed some work on increasing traffic flow with respect to buses:

> 'whatever particular bus it was, they have reduced the time on this stretch of road by 20%. … If you … achieve 20% across the full route … what are the implications of that? So what does that do for the GDP of the city? … A lot of the things can be multiplied. So you run a solution on this junction controller or this bus route and you apply the logic of that … to 40 junctions and 50 bus routes. And every bus then, all of a sudden, is 20% quicker.'

As Wacjman (2008) notes, new technologies do not simply speed-up processes and actions or save time, but can change their nature and meaning, as well as introducing new material 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.

Third, *acceleration of social change*, in which social relations (such as attitudes, values, practices, habits), structures (such as communities, workplaces) and institutions (such as public services) increasingly lack stability and change in constitution on an increasing basis (Rosa 2003). While in the Global North these shifts are predominately social changes, in the Global South the acceleration of change is occurring across all domains of life and involve large migrations and rapid urbanization – the production of what Datta (2017) terms 'fast cities'. Smart cities cast urbanization as an opportunity not a challenge, with the speed of change being met by an acceleration in response enabling emerging crises to be met and dealt with (Datta 2017). So while smart city technologies work to accelerate life, they are also pitched as the means to measure, manage and cope with such an acceleration. As Roth (2003: 14) notes, '[t]he ensuing needs for synchronization and selection of increasing (future) options can in turn only be satisfied if the processing itself is accelerated.' Fast urbanisation speeds up, optimizes and makes more efficient administration, planning, service delivery, policy formation, and infrastructure provision (Datta 2017).

Temporal modalities

As well as the temporal rhythms and relations of cities being transformed through the drive to make them smart, a key aspect of how smart city technologies work is how they draw upon and reconfigure the relationship between the past, the present, and the future. Smart cities seek to leverage information about the past and those generated in real-time in order to manage more efficiently and effectively the present and to anticipate and shape the future. They are technologies that seek to use time as a resource, working across temporal modalities, in order to produce new space-times in the present and future. Here, I want to consider the temporal work of smart cities with respect to what Adam and Grove (2007) term 'past present', 'present present', 'future present' and 'present future'. 'Present' is the common denominator because, as Dodgshon (2008: 7) notes, while we apprehend the past (before), present (now) and future (after) as different perceived forms of time, experientially they do not have an existence outside of the present. The past is always reinterpreted afresh by each generation with history revealed in its 'current truth' (Koselleck 2004: 242), and the future reimagined with evolving expectations (Dodgshon 2008). Four ways in which we know the past, present and future from the present are hindcasting (building a model of how things worked in the past), nowcasting (using real-time data to predict present and very near future conditions), forecasting (using the present to predict the future), and backcasting (working backwards from a desirable future scenario to identify policies and interventions to lead from the present to that future).

The latter two, in part, distinguish ‘present future’ and ‘future present’. The ‘present future’, according to Adam and Grove (2007), is the future from the standpoint of the present. It is the future to be created, which unfolds from past and present trends, the result of given and embedded structures and individual embodiment (Poli 2015). It is the future ‘imagined, planned, projected, and produced *in* and *for* the present” (Adam and Groves 2007: 28). Future present, on the other hand, uses the future in the present, using possible or anticipated future outcomes to rethink present practices which then reshapes the future created (e.g., using predictions of climate change outcomes to change policy and activities in the present in order to realise a different future) (Adam and Grove 2007; Poli 2015). Adam (2008) thus notes that the present future positions the future as ours ‘to shape and create’, with current economic, political and institutional practices ‘tak[ing] from the future for the benefit of the present.’ The future present acknowledges that our present actions potentially impact on future generations and we can act morally and ethically to create a different world (Adam 2008). From this perspective, the present future is about politics and future present about ethics (de Lange, in press). Smart cities are the result of the anticipatory logics of future present (White 2016), but by-and-large work to create the present future. In both cases, the future is not simply waiting to happen, but is active in the present.

Past present

There is a long history of urban data being generated as a way to understand and manage cities. Much of these data, and the subsequent information produced from them, are preserved in archives/repositories. These data provide an evidence basis for both understanding past events and conditions and for managing the present and planning the future, with the latter extrapolated from the historical record. Until recently, all evidence-informed analysis was based on past data, even if that data was generated relatively recently. For example, national censuses formed, and continue to form, a key demographic, social and economic evidence basis for form formulating policy. Conducting a census is a mammoth undertaking, with the data generally only available for analysis two years after collection. The data are also a time slice, collected on a single day every ten years. In this sense, they are an example of what Dodgshon (2008: 2) terms $space^{time}$, wherein time is treated in a way subordinate to space. Here, the data primarily deal with geography *in* time, rather than geography *through* time.

The data thus give an overview of what the situation was a particular time, but little sense of the underlying processes and how these evolve over time. That is not to say that there is no time-series to the data, but that data sampled every ten years provides only a sense of trends in a very broad terms.

In most cases, datasets are also sampled across space as well as time. In these cases, time can often be the key aspect of the data, especially for data generated on a weekly, monthly, quarterly and yearly basis, enabling time-series analysis. In recent years, big data that are generated at specific sites but on a continual basis are being archived to provide a new level of granularity (every few seconds, minutes) in historical records of particular systems using networked sensors and cameras. As the head of the traffic control centre (SDP43) detailed.

> 'Yeah, we would keep our traffic counts and our traffic data for years and years and years so we would be able to go back and see what way the traffic flows have changed. As part of all this we would have air and noise quality measurements and modelling which is done as well. So, yes, we would have a pretty good idea of how things have moved over the last period of time.'

In many scientific studies, both the spatial and temporal sampling might be one-off endeavours, providing limited space-time information. One-off datasets have limited utility for smart city initiatives, which engage in continual, on-going management of urban systems and infrastructure, but time-series data continue to provide an important resource. For example, such data are often used in city dashboards to visualize and monitor how a city is performing over time and to simulate and forecast/predict future outcomes (Kitchin et al., 2015) or become part of the wider geoweb and spatial media (Ford and Graham 2016). Here, historical records are accessible in an instant and can be interrogated using interactive tools. In the interactive mapping system being developed by a startup entrepreneur (SDP42), he explained such an application, in this case linking very recent data (last week) to historical data (last 37 years):

> 'But coming back to the heartbeat of the city, the data that we have tells you everything that is happening in the city on a daily basis and not just what came in this morning but what happened back in 1980. So we could look at any building in the city, identify it and tell you the full DNA or that building. When it was applied for permission first, when the first block

> was made ... But what that allows you to do then is analyse the city and say, how many retail applications above 10,000 sq. feet came in in the last week across the whole country? … And that is where we are looking to get to, to be able to analyse the whole city and say in the last year this is where all retail went to. And then you go back to 1980 and you look at those curves and ... [tails off]'

Present present

> '[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' (SDP1, city administrator).

A significant part of the appeal of smart city technologies is their seeming ability to enable city systems to be used and managed dynamically in real-time taking account of present conditions (Bleecker and Nova 2009; Kitchin 2014; de Lange in press; Luque-Ayala and Marvin 2016). Data concerning the activity and performance of an infrastructure or system are generated by sensors, actuators, transponders and cameras and fed back to a control room for human oversight, or processing by a management system which can instantaneously process and analyse data and respond as required. These data can be shared via publicly-facing dashboards, APIs and open data repositories, and plugged into mobile apps. Such control rooms and dashboards seek to create instantaneous corrective actions before problems grow and multiply, to manage emergencies and conduct surveillance, and to create more efficient and optimized system operations, as well as providing accountability and transparency, and a resource for civic hacking (de Lange in press; Kitchin et al., 2015).

The increasing availability of real-time data seemingly creates an annihilation of space *and* time to the point where governance is enacted in a perpetual present (de Lange in press). Here, temporal succession is seemingly erased to windows of short durations (Virilio 1997), with 'events mapped as isolates and reduced to singularities', where systems identify and respond to out-of-the-ordinary occurrences so that dealing with the exceptional becomes routinized (de Lange in press). For Virilio (1997), the ability to perceive and respond to distant events in the world in real-time creates what he calls 'chronoscopic time' (rather than chronological time). Writing with respect to the real-time media coverage of global events and the general use of telecommunications, he argues that rather than unfolding successionally as a conventional narrative of before, during and after, or events being documented after the fact, audiences and workers have become accustomed to the real-time instant in which narrative time implodes (Purser 2002). In other words, 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. People have thus become fixated on knowing and taking part in the present – checking for new emails and responding, seeking out current news or weather, browsing the newest posts on social media and commenting, checking-in to places on locative media, discovering when the next bus/train is due, and checking quantified self performance metrics.

An aspect of this fixation with knowing the present is the practice of nowcasting: predicting the present, the very near future (micro-seconds to a few days), and the very recent past (micro-seconds to a couple of months) (Bańbura et al., 2010). Nowcasting has been the prevalent form of weather prediction – to report conditions across space at the present time and very near future based on samples at particular locations. This has recently been extended to other domains such as economic indicators to understand very recent conditions ahead of official statistics and to predict market movements, and traffic flow across a road network including roads not surveyed. Likewise, predictive policing seek to nowcast patterns of crime in order to direct police patrols accordingly. As Uprichard (2012: 133) notes, the aim is often not simply to know now, but ‘to know about now before now has happened’. 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.

Despite the fixation on the present, real-time data if recorded do provide a record of temporal processes, of change through time, rather than a snapshot in time, in contrast to space^{time} data that freezes the world at a particular moment (Dodgshon 2008). Such recording reveals that real-time data are never quite in real-time, being sampled with a small latency between discrete data points that corresponds to their refresh rate (Mackenzie 1997; de Lange in press; Kitchin and McArdle 2016). In their comparison of different streaming social media and news platforms, Weltevrede et al (2014) detail that they each have 'varying lengths, modulations, qualities, quantities and granularities' in the back-end processing and delivery of content (Berry 2011: 144)'. In other words, there are varying forms of 'realtimeness', with a number of distinctive 'real-time cultures' that follow specific update cycles that are algorithmically determined (Weltevrede et al 2014: 137). As Kitchin and McArdle's (2016) comparison of 26 types of urban big data highlights there is a diffuse set of realtimeness operating within smart cities across specific infrastructures and spatial media. The temporal sampling timeframe has consequences as one of the respondents detailed (SDP22, a university researcher):

> 'You need to choose the interval in which you retrieve the data. Because if you retrieve them every second you have plenty of information, but there also can be much noise. If you retrieve them every hour it is more normal but you can lose information, so you need to find a compromise, the right balance. … [T]he higher the resolution, the higher the consumption of battery; the more you keep data in the flashcard, the more you have to transmit them. There is a whole series of compromises you need to deal with.'

A number of commentators 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 strategies of creating space and time for asynchronous smart cities (see Purser 2002; Bleeker and Nova 2009; Uprichard 2012; de Lange in press; Datta 2017). In essence, they challenge the emphasis on optimization, efficiency, speed and whether 'now' is always the right to time to act, and consider the consequences of such responsiveness particularly to fostering technocratic forms of governance and creating temporal density and time squeezes (see Kitchin 2017 for further discussion).

Present future

Leccardi (2007) details that the future used to be the realm of God and nature, with society looking backwards with respect to living in the present. Since the Enlightenment, he contends that society has increasingly looked instead to the future to shape the present through its own actions, with anticipation and expectation prevailing over habit, memory and fate. Consequently, the future is not seen as open field of possibilities but one that progresses along a contingent and relational set of path dependencies produced by society. People thus formulate strategies and plan and direct action in the short-to-medium term to try and realise particular futures, and to forecast the future based on the present situation and certain assumptions concerning how systems work and situations might unfold socially and politically. In both cases, there is an extrapolation from the present, with the anticipation that the system under consideration will continue to work more or less as it has been. For some, such as stock market traders and insurance brokers, the future is a commodity to be traded (e.g., speculating on future yields, interest/credit, risk of insurance payouts) (Poli 2015). For others, the future is a possible scenario to be nurtured and realised. The future then is imagined and planned from the present, with current rhetoric and actions creating pathways to try and realise particular future outcomes – though achieving those outcomes is uncertain (Adam and Grove 2007; Poli 2015). Indeed, Amara (1981, cited in Poli 2015) details four types of future: possible (those that can be imagined), plausible (those that could be realised given present knowledge), probable (those that are likely given present trends), and preferred (those that are desired).

Such future contemplations recursively impact on how the present is managed in order to try and realize particular futures; in other words, just as the present pre-figures the future, the 'future acts as a determining condition of the present' (Uprichard 2011: 110). The present and the future, and the unfolding of time, is thus produced, often in highly contested ways (different factions seeking to create varying outcomes through shaping public opinion and actions, public policy, and violence) – for example, debates concerning the unfolding and tackling of future climate change. Fate, as such, takes place within a pre-figured context, though there are dispositions always at work. As Poli (2015: 89) details '[d]ispositions are facts with an anchor in the future; they are facts that can happen if the relevant triggers are activated' – a glass dropped on a hard floor will shatter; the glass may not fall, but there is always a possibility it will.

Smart city technologies, while most often framed around managing the present, are future orientated with respect to plausible and preferable scenarios, dispositions, optimization and contingency, and what Adam (2008: 8) terms a 'timeprint' (the temporal futures equivalent of an ecological footprint). Technologies such as flood monitoring and management seek to be reactive to the disposition of a flood, which is maybe an infrequent possibility but a certainty if there is a certain amount of rainfall, along with other factors such as high tides. Similarly emergency management response seeks to anticipative and be reactive to potential dispositions, such as a terrorist event. Such an approach seeks to realise what Miller (2007, cited in Poli 2015) terms contingency futures; that is, preparation for anticipated surprises. In contrast, a system such as a traffic control centre seeks to produce optimization futures, imposing patterns and trends from the past on the future through causal-predictive models (Poli 2015). Large-scale smart city investments, including new infrastructure or entire new districts or cities (e.g., Songdo in South Korea or Masdar in UAE) shape city form and how it will function for decades. The smart city movement actively seeks to shape future urbanism and create an extended timeprint - to create cities that are more liveable, sustainable and resilient in the future. Smart city technologies thus produce what Adam and Grove (2008) term 'latent futures' – futures in the making that are 'on the way' and still have to surface and become visible (Poli 2015). The smart city then aims to determine city futures for future generations, taking away the ability to fully self-determine the nature of urban life from them (Adam 2008). Such inherited legacy is the fate of every generation, though some legacy is emancipatory and empowering and others are burdens.

Future present

> Interviewer: "So what you are suggesting in a way is we move to a model of backcasting, so we kind of say, this is where we want to be in ten years' time, how do we get there and how do we ensure that if there is privatisation of the buses that they do still stay in the Leap Card system for example or whatever it might be?"
>
> SDP38: "Yes, and also accept that in five years' time somebody is going to come up with a ground breaking invention that is going to wipe out about three years of what we talked about doing."

Whereas the present future extends the present into the future, the future present uses possible futures to consider and plan alternative trajectories (Adam and Grove 2007). For example, the practice of backcasting imagines a normative future – some state that we might wish to achieve – then works back to the present to try and define the steps or pathway needed to make such a future a reality. This normative future is in contrast to other potential futures, ones that are not so desirable or contain threats and which might be realised if the present future is allowed to unfold unchecked. In this sense, Anderson (2010) argues that a normative future is evoked in order to pre-empt, prepare for, or prevent threats from being realised, and to redirect present future paths onto a new trajectory. The future thus 'becomes cause and justification for some form of action in the here and now' (p. 778). This occurs, he contends, through the assembling of styles (statements about the future that set out and limit how it should be framed and acted upon), practices (acts of performing, calculating and imagining that render the future present through materialities, epistemic objects and affects), and logics (policies and programmes through with the action in the present is enacted).

As White (2016) details through a critical examination of smart city marketing materials, industry documents, and consultancy reports, smart city advocates have developed a set of styles, practices and logics that map out and draw extensively on future scenarios to both rationalize technological intervention in the present and to pre-empt and plan new urban trajectories that seek to realize those scenarios and avoid anticipated threats. In the smart city case, White argues that three crises act as a motivator for imagining alternative futures: widespread changes in patterns of population, particularly rural to urban migration, and subsequent resources pressures; global climate change and the need to produce more resilient cities; and fiscal austerity and the desire to create leaner governments and attract mobile capital (also see Datta 2017). By evoking alternative future imaginaries and contrasting them to a present future that fails to take a path of investment in smart city technologies and approaches, advocates seek to pre-empt and prepare the ground for a new form of urbanism that will more effectively respond to existing and coming crises and realise their imaginaries (or at least lead to massive investment in their products).

For Poli (2015) such expectations operate as 'real fictions'; they are not mere fantasies because actors develop and seek to realise plans based upon them. As such, they cannot be assessed or challenged on the grounds of truth or falsehood, but can only be properly opposed with respect to whether they are convincing or not. As Datta (2017) notes, smart cities 'claim to deal with the present by seizing the future … The future cannot be measured and called to account since it has not yet materialized.' The future present smart city is thus somewhat slippery, powered by its discursive imaginaries and arguments and a smart city epistemic community and advocacy coalition (Kitchin et al., 2017b) which work to create convincing 'logics through which anticipatory action is legitimized, guided and enacted' (Anderson 2010: 777). Such logics have appeal because city administrations and companies mostly operate in the future present, rather than being more proactive about envisioning and creating the future, as the manager of a multinational company (SDP30) stated:

> "[I]n our business today we are focused week to week, quarter to quarter, year to year, and then occasionally we stretch out to maybe 3 years, and the people in the senior leadership teams would be looking 5 years, but who the hell knows what it is going to be like in 5 years

> or 20 years?”

Smart city imaginaries seek to remove some of this uncertainty and try to limit the multiplicity and contingency of the future. As such, smart city technologies are deployed in part ‘on the basis of what has not and may never happen’ (Anderson 2010: 777) but in so doing pre-figure the future city.

Conclusion: The smart city as space-time machine

In this paper I have sought to explicate the temporality of smart cities, detailing various ways in which smart cities mediate and are mediated by temporal relations, rhythms and modalities. In essence, what I have done is mapped out the timescape of smart cities, summarized in Table 1. Adam (2004) contends that within a timescape time is multiplex in nature. Indeed, the analysis reveals that the smart city has a ‘multiplicity of space-times’ (May and Thrift 2001: 3) and acts as a space-time machine, producing new temporal relations in which network time, clock time, social time, natural time, past, present and future co-exist to create a new set of intersecting rhythms, beats, sequences, tempos, and temporal patterns and arrangements. The temporality of the smart city is multiple, heterogeneous, and dynamic with numerous temporal relations and rhythms unfolding through a diverse set of contingent and relational processes that are intimately enmeshed with spatiality. As Crang (2007: 84) concludes:

> ‘There are multiple speeds implied in network time-spaces. Rather than thinking simply of an endless onward rush, we might look at them as a turbulent-torrent. There are back eddies, ripples, fast parts, slow pools, and so forth, and flows may be braided and overlain (Grosz 1999). Some people may be slowed, others accelerated. Some times may be densified or fragmented and others extended or attenuated in long waits.”

What the analysis thus highlights is that there is a need to consider in much greater detail the temporality and timescapes of smart cities and the ways in which smart cities act as *space-time machines* – transforming urban spatio-temporal relations and rhythms, and enacting different temporal modalities wherein the past, present and future are evoked and utilised simultaneously but in different and sometimes paradoxical or frictional ways. While the full multiplicity of temporality detailed in Table 1 requires further elaboration and research, there are three temporal aspects of smart cities I believe require particular attention.

Table 1: The timescape of smart cities

Temporal rhythms/cycles and representations	*Temporal rhythms* cyclical and linear cycles; polyrhythmic, eurhythmic, isorhythmic, arrhythmic patterns; algorhythm; periodicity	*Natural time* Earth seasons; diurnal cycles; body clocks; turning of tides	*Social time* national holidays; celebrations; festivals; holy days; working hours; rush hour; family meal times; timetables; deadlines	*Clock/measured time [Chronos]* second; minute; day; week; month; year; decade; century; millennia; 24/7
Temporal relations (Experienced time** [Kairos]**)	*Time-space compression* time-space convergence and distanciation; global present; instantaneous time; timeless time	*Scheduling* just-in-time; peak time; sequence; prioritisation; continuity; frequency	*Efficiency* saving time; synchronicity; latency; delay; first/second mover	*Pace and tempo* speed; acceleration; refrain; repetition; duration; ahead/behind the curve; statis/inertia; time flies/drags; fast urbanism
Temporal modalities	*Past present* History; memory; evolution/change; trend; hindcasting	*Present present* real-time; network time; chronoscopic time; on-the-fly; of-the-moment; serendipity; always-on; nowcasting; plastic present; code/spacetime	*Present future* forecasting; speculation; prediction; short/mid/long term	*Future present* anticipation; preparedness; backcasting

First, there is a need to examine in detail what is perhaps the signature time of smart cities – realtimeness – and its nature and consequences of city administration operating in so-called real-time. As the analysis highlights, realtimeness is fabricated and multiple; varying across infrastructures and spatial media as function of their socio-technical arrangements. Further, there is an unevenness in the distribution of real-time systems, with it deployed in key locales first and then distributed to other parts of a city. Moreover, while governance seemingly happens in a perpetual present, space and time are far from annihilated. While real-time analysis/action is widely celebrated as a benefit, enabling instantaneous monitoring and control, there are also risks with focusing on the here-and-now, prioritizing optimization and efficiency over other considerations, and overly relying on algorithms to manage systems, though such risks are largely undocumented. Applying Weltevrede et al's (2014) approach to smart cities would, I believe, productively unpack the pacing and fabrication of realtimeness by devices, actors, infrastructures, and activities, and their social, cultural, economic and political framing, and the practices they incorporate and enable. Early examples such research include de Lange's (in press) examination of real-time urban dashboards and Coletta and Kitchin's (2017) unpacking of the algorhythms of a traffic control room.

Second, such research needs to be accompanied with a stronger understanding of the ways in which software/algorithms are mediating the production of space-time. Indeed, in terms of the everyday functioning of the smart city in many cases time unfolds as what might be termed code/spacetime (extending the notion of code/space forwarded by Dodge and Kitchin (2005)), wherein space-time relations are dependent on smart city technologies to be produced in particular ways. 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. If the code fails, in the sense of the system crashing, then the traffic lights either fail to work or operate on default settings, meaning the space-time intended is not transduced. On one occasion I was present in the Dublin traffic control room when a visiting government minister asked the supervisor what would occur if the system failed. He was asked if he remembered the serious traffic congestion the previous Tuesday in one part of the city that had knock-on consequence across the road network, then told there was an infrastructural fault that had taken the system offline across a number of key junctions. The unfolding space-time of traffic flow dropped into a state of an uncoded space-time and experienced severe arrhythmia. Indeed, the production of code/spacetime is largely an attempt to create eurythmia and to produce a consistent refrain, or as Edensor (2010: 11) states to produce 'rhythmic conformity and spatio-temporal consistency through the maintenance of normative rules and conventions about when particular practices should take place at particular times.' In other words, code/spacetime works to create particular temporal rhythms, tempo, pace and scheduling and to combat entropy, subversion and breakdown. Several code/spacetimes unfolding simultaneously produces the smart city as a 'polyrhythmic assemblage' (Edensor 2010; Coletta and Kitchin 2017). As yet, however, we have little detailed understanding of how such realtimeness and code/spacetime work in practice.

Finally, there is a pressing need for analyses of politics of time in the smart city. New, distributed and mobile ubiquitous computing is transforming the temporalities of cities, but whose interest do such changes serve? Do they create a more just city, or do they work for the benefit of capital and states? My analysis suggests that smart city technologies are less likely to align and subordinate their temporal practices to the wider tempo and temporal frames of the city, rather they seek to influence and dominate the tempo – to proactively manage rhythm and temporal relations. In particular, they seek to produce the rhythms desired by governmentality and capital – to create a symphonic ordering of society and economy that is disciplined, controlled, and enables the practices of production (Conlon 2010; Vanolo 2014). It is the case that spatial and locative media provide individuals with temporal flexibility in scheduling, though such media operate as platform economies, with peoples' space-time movements being commodified. In other words, while citizens might benefit from the deployment of smart city technologies through enhanced optimization and efficiency of services and new apps that facilitate consumption choice and individual autonomy, this takes place within a framework of constraints that prioritize market-led solutions to urban issues, reproduces neoliberal capitalism, enforces technocratic modes of governance, and continues to perpetuate inequalities between communities (Cardullo and Kitchin 2017). Time is thus leveraged for the benefit of some at the expense of others. As Shaban and Datta (2017) have recently argued, perhaps what the politics of time in the smart city demands is 'declerated urbanism'; a slowing of action and de-prioritisation of speed in order to more carefully consider 'processes of democracy, citizenship, sustainability and belonging in the making of cities' in order to create a more temporally just smart city.

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